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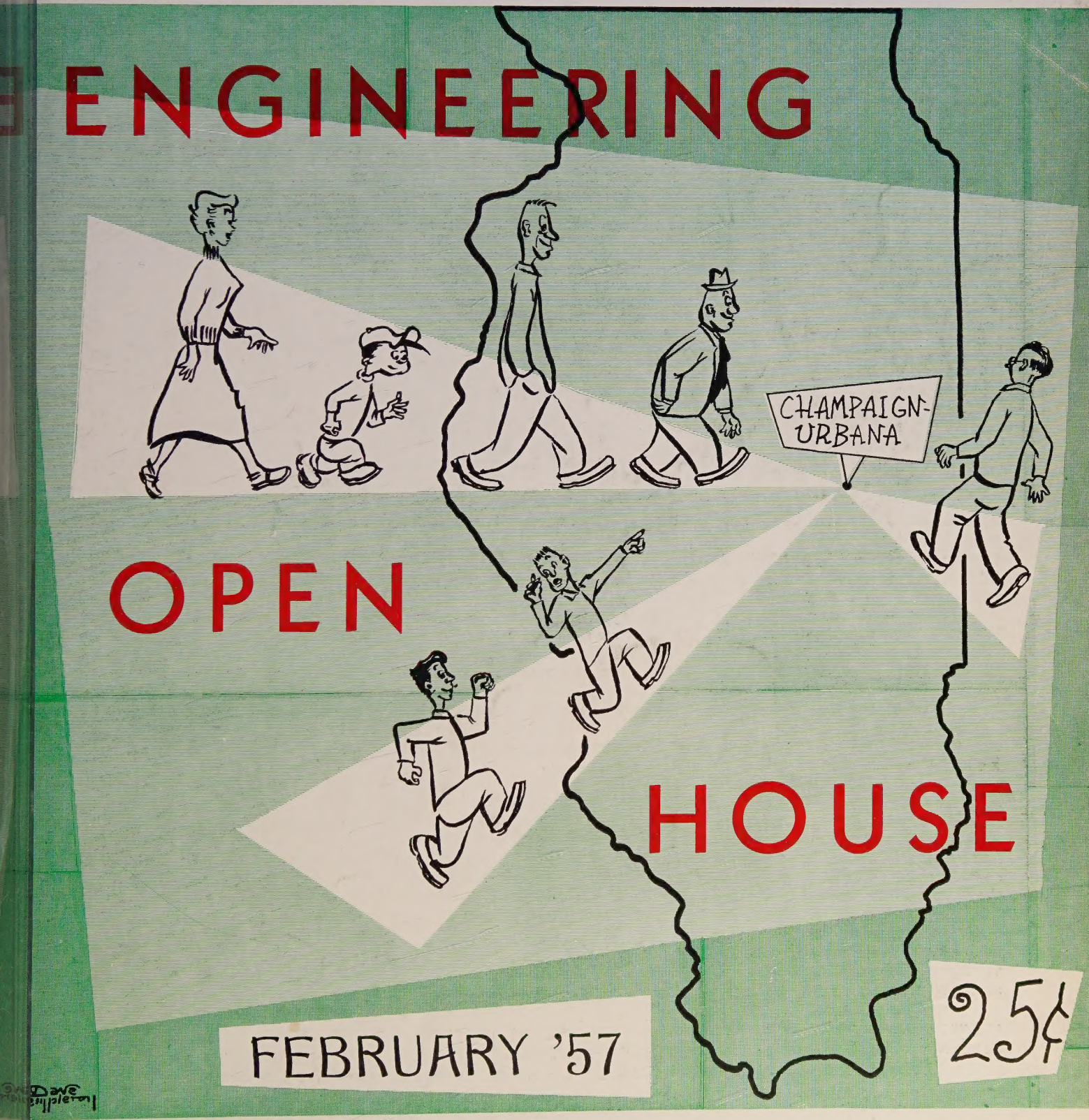
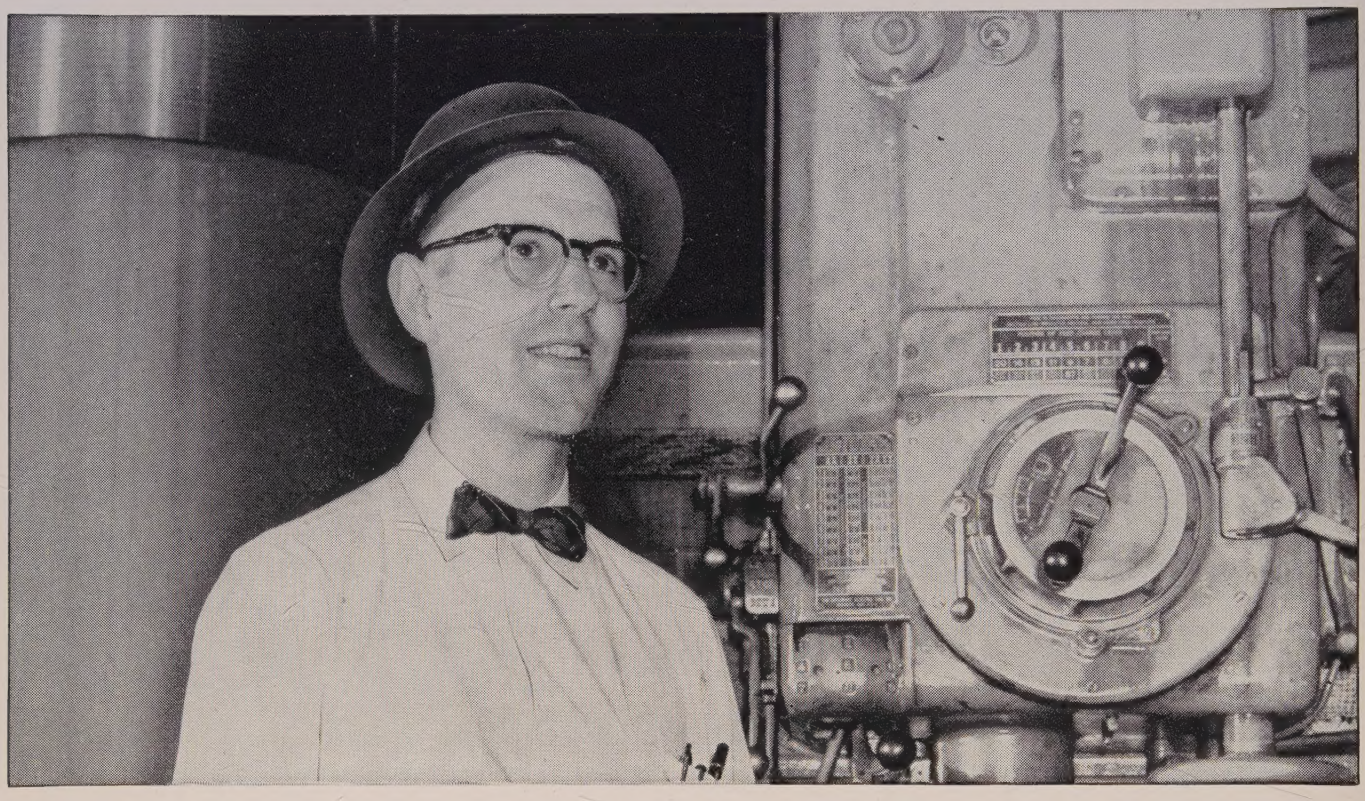
ILLINOIS TECHNOGRAPH



Frederic F. Berman, class of '46,
speaks from experience when he says . . .

"Personal satisfaction and happiness within your working atmosphere are among the many compensations at U. S. Steel."



Graduating with a B.S. in Mechanical Engineering in 1946, Mr. Berman first entered the employ of U. S. Steel's National Tube Division's National Works on April 10, 1950, in the estimating division of the Maintenance Department.

On May 1, 1951, he was advanced to the post of Process Engineer of the Maintenance Department. He was promoted to Assistant Superintendent of the Maintenance Division on December 1, 1951. On January 1, 1955, he was elevated to his present position of Assistant Superintendent, Maintenance Department, Shops and Services Division. This indicates considerable progress within the short span of five years. And yet this "success story" is typical of the hundreds involving young and ambitious engineering graduates who take advantage of every opportunity to grow and progress under the effective management training programs which are offered by United States Steel.

Today, Mr. Berman has responsibility over six groups: General Machine Shop, Shops and Service, Masonry Department, Building Service Group, Electrical Group, and General Labor Department. In the various phases organized under these groups, he supervises an army of 1300 men.

Mr. Berman sums up his philosophy toward his job and co-workers in this way: "Working for U. S. Steel is similar to the feeling one has for family life. Although it is a large operation, we are a closely knit group. Here there is an atmosphere of interdependence. Each man helps the other. Liking what you do is the key to a successful career. Personally, I like working for U. S. Steel. And you just can't help liking the people with whom you are associated here."

If you are interested in a challenging and rewarding career with United States Steel and feel that you can qualify, we suggest that you get in touch with your college placement director for further information. Also, we shall be glad to send you our informative booklet, *Paths of Opportunity*, upon request. Write to United States Steel Corporation, Personnel Division, Room 1662, 525 William Penn Place, Pittsburgh 30, Pa.

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THE ILLINOIS TECHNOGRAPH

Volume 72 **Number 5**

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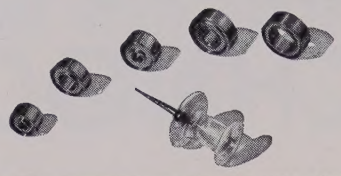
Frontispiece . . .

The Illini Union is commonly called the "front door to campus." Facing Engineering Campus on the south, it is a center of social functions on the UI campus. (See Page 24.)

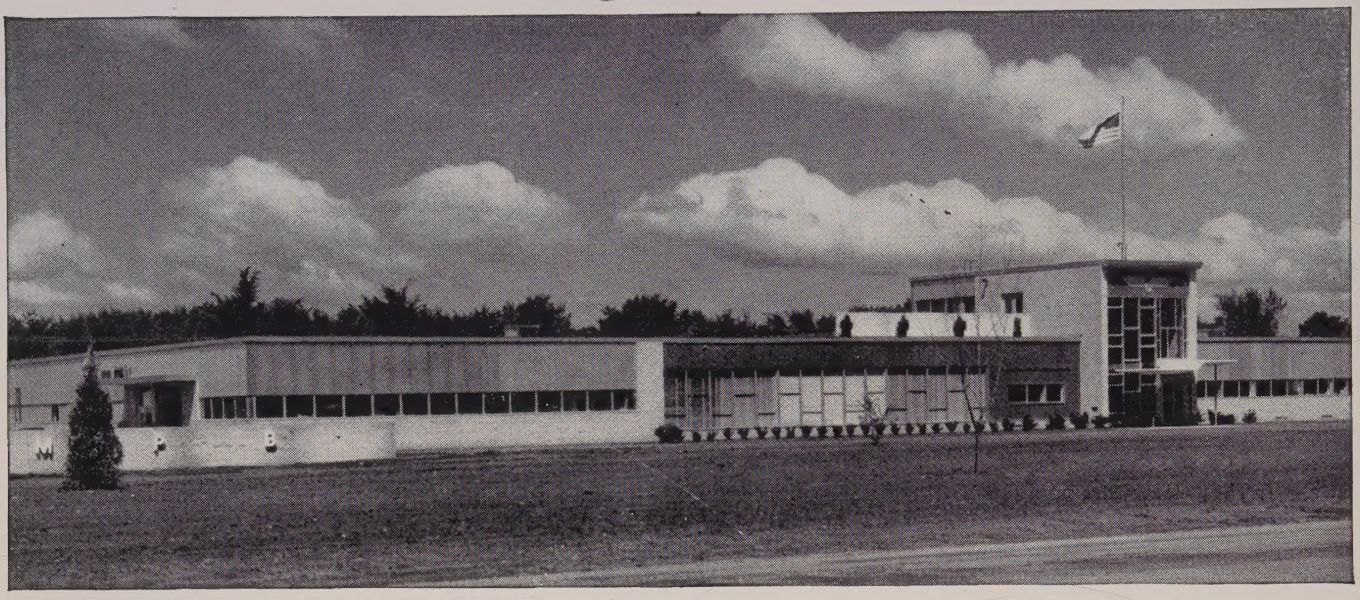
Cover . . .

All roads lead to Champaign-Urbana, scene of Engineering Open House March 15 and 16. High school students and other interested persons from all parts of the state will attend to witness the exhibits.

a new home for the WORLD'S "SMALLEST BUSINESS"



Miniature Precision's line of miniature and sub-miniature bearings includes more than 500 different types and sizes. The smallest of the bearings shown with the push pin has an outside diameter of 1/10th of an inch; is 3/100th of an inch thick, and has a 1/40th inch bore.



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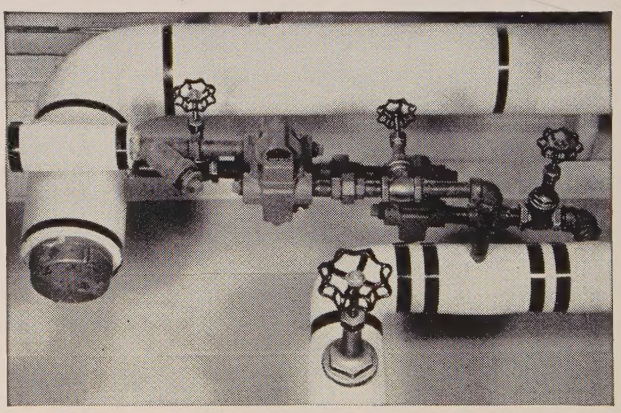

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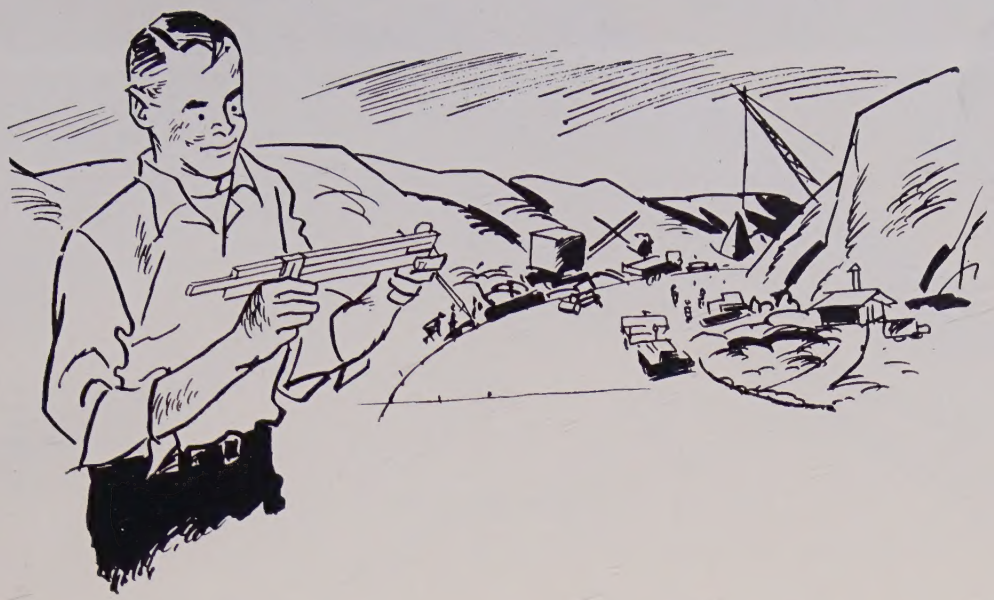


An Engineer. . .

(The following editorial was printed in our last Open House issue. What we said then still holds true.—Editors)

What is an engineer?

Those of you who are visiting campus for Engineering Open House are looking forward to entering the profession, but probably aren't quite sure what an engineer is. You February freshmen are in the same boat. Ask an LAS, or other type of non-engineering student, and he'll give you a ready answer. An engineer to him is a noncultured boor, who thinks he's going to run or ruin the whole world. Ask an engineering student and he'll say he's so busy studying to be one, he doesn't have a chance to think about it. Read the magazines, or newspapers and you will see that the engineer is the front man in the development of American know-how for building bigger and better weapons and bigger and better instruments of peace.

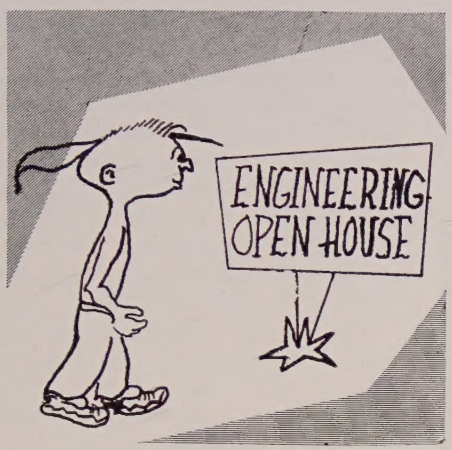
An engineer is more than an attachment to a drawing board or an accessory to a slide rule, or unlearned, yet high-salaried technician.

Engineers of today are the executives of tomorrow and that's no joke. The man who becomes an engineer, if he sticks to IT, becomes a dedicated man. It's easy to take the courses offered in colleges of engineering and think you're it. But you're not. You're not an engineer until you are a citizen as well as a technician. The ever-increasing demands upon the profession compel it to come out from behind its drafting table and take its own seat at the table of working, acting, thinking leaders of America.

Not only must the engineer recognize this, but the public must also be aware. That is why we have Engineering Open House and why we have National Engineering Week. To let the people know, "What is an engineer?"

H. H.

The Engineering Open House



The College of Engineering opens its door for an annual inspection of its facilities by the people of the state

by Harry Hirsch, E.E. '57

Preparations are in full swing for the 51st year of the College of Engineering's annual weekend wing-ding, Engineering Open House, March 15 and 16.

This annual opening of the doors of North Campus to all interested visitors was begun in 1906 by members of the Physics department. Its purposes are:

(1) To prove to the people and industries of Illinois and the nation that there is no such word as "static" in any field of science, be it research, production or management.

(2) To offer to the prospective engineer an idea as to the duties necessitated by any particular phase of engineering as well as the training and type of individual that such a field requires.

Exhibits prepared by student groups in the College will be open to all interested high school students, citizens of the state who wish to see where their tax money is going and South Campus residents who aren't quite sure what an engineer does. The exhibits, which are prepared by students with a minimum of aid from the faculty, will feature displays, demonstrations and regular showings of apparatus, equipment, processes and brain storms.

Included will be several exhibits from various industries, including Sperry Gyroscope Co., which will display in the Aero and Electrical Engineering departments. The Sperry exhibit will include displays on inertial navigation, coordinated airborne radar sets, automatic flight control for jet transports, traveling wave tube and klystrones, ship stabilization, guided missiles and semi-conductor devices.

While many of the displays are intended to give a capsule demonstration of what an engineer does, their format will also be of an entertaining nature.

Lets take a mythical tour around campus to see what will be on display. Publishing deadlines do not enable full details to be given to each exhibit, many of which were still in the format stage as this magazine went to press.

Starting point for tours is the Civil Engineering Building, which once housed the entire College of Engineering. Here engineering honor society members will take groups of students around campus or individuals may consult their program as to what to see. White lines painted on the sidewalks and maps included in the free guidebooks will facilitate touring.

Exhibits in Civil Engineering Hall will include bridge models, a weight measurement device, model construction site, traffic interchange models, a display of fluoridation of public water, equipment used on field surveys, railroad signal equipment and movies of Civil Engineering projects under construction. Just west of the Civil Engineering Building will be an operating water treatment plant taking water from Boneyard Creek and purifying it.

Crossing Burrill Ave., one enters the Electrical Engineering Building. On the first floor will be displays from the Math department showing the application of mathematics to engineering. Electrical Engineering displays will include servomechanisms, hi-fi sound reproduction, transistors, household wiring, power system apparatus, radar, sonar, microwave and special lighting effects in the Illumination Lab. Novelties will be the electronic remote control locomotive and duck as well as an operating "Kiss-o-meter."

Leaving the Electrical Engineering Building via Wright St., and traveling north across the Boneyard is Talbot Lab, home of Theoretical and Applied Mechanics. The TAM monster, the three-million lb. testing machine, will be in operation breaking large concrete cylinders and measuring pressure required for rupture. Other displays will be torsion, tensile and compressive strength testing machines, water turbines, rail and joint bar testing and fatigue loading as well as movies on

student activities in the department. Back across Burrill Ave., to the Foundry, are displays on sand testing which include core making, drying and sand blasting. Demonstrations of casting and foundry methods will be given on the main floor.

Aero Engineering Lab B, just south of the Foundry, will have displays of aircraft, structural framework, landing gear, engine models, including rockets, jets and reciprocating engines.

On display in the Engineering Research Lab, just east of the Aero Lab, will be Illiac, the UI digital computer. One of the largest in the world, it will be computing actual research problems during Open House.

The adjoining Mechanical Engineering Lab will house demonstrations of turbines, high altitude test chambers in the Physical Environment Lab and power machines. Ag Engineering exhibits in the building will show the latest improvements in farming due to engineering methods.

Across Mathews Ave., is the Transportation Building, home of General Engineering. Here will be displays of production illustration, descriptive geometry, machine and architecture drawing, geological and perspective drawing and aircraft drafting and lofting as well as many demonstrations on letter machines, and reproduction of drawings.

At the north east corner of North Campus are the Mining Lab, Metallurgical Lab, Aero Engineering Lab A and Ceramics Building. Exhibits in this order will be prospecting, diamond drilling, fuels and mining equipment and methods. The Metallurgical Lab will feature displays on production of metals, microstructure and the electron microscope. A wind tunnel will be operated every half hour in Aero Lab A. The Ceramics Building will have displays on abrasives, porcelain enamels, glass, whitewares and structural clap products.

South of the Boneyard once more is the Cyclotron where frequent demonstrations will be given.

West again at Mathews and Green is the Mechanical Engineering Building. Here Industrial Engineering displays of tool design, time and motion study, industrial safety and plant lay out and materials handling will be on hand. Mechanical Engineering exhibits include operations with special machines in the Machine Tool Lab, treating of metals in Heat Treatment Lab, welding, heat transfer study, operation of automotive gas and diesel engines and elements of machinery. An Army ROTC display will also be found.

Venturing south of Green St. to the East Chemistry Building on California and Mathews one finds demonstrations of Chemical Engineering. These include synthetic textile manufacture, electrochemistry and chemical magic.

The by-now somewhat weary individual who heads back to Engineering Campus will find demonstrations of heat, light, mechanics and electronics in the Physics Building.

Frequent bus service will be provided from Mathews and Green to the Physics Research Building where demonstrations of the Betatron will be given. Nearby is the Abbott Power Plant which will be open for inspection. Power-generating machinery under operating conditions will be on display.

Tentatively scheduled to be on the Illinois Central railroad tracks near Abbott Lab will be a test train of dynamometer test car, rail test car and the latest type of diesel locomotive.

All this, plus movies at many displays will be on hand from 10 a.m. to 10 p.m. Friday and from 10 a.m. to 5 p.m. Saturday. Information on exhibits and parking may be had in the first floor of Civil Engineering Hall Refreshments will be sold in the Mechanical Engineering Lab and the Electrical Engineering Building.

With the close of Open House Saturday afternoon, eager engineers will venture to Huff Gym with their dates for the annual St. Pat's Ball. Highlight of this affair will be the naming of the honorary Knights of St. Pat, chosen on the basis of activities and scholastic endeavor and knighted by St. Pat, the patron saint of engineers, himself. A new feature of the dance will be the selection of a St. Pat's Ball Queen who will reign as darling of the engineers. Buddy Morrow's orchestra will supply the music.

For further details, don't miss the big show. See you March 15-16!

FREQUENT DEMONSTRATIONS WILL be given of the giant Talbot Lab testing machine as it smashes concrete blocks

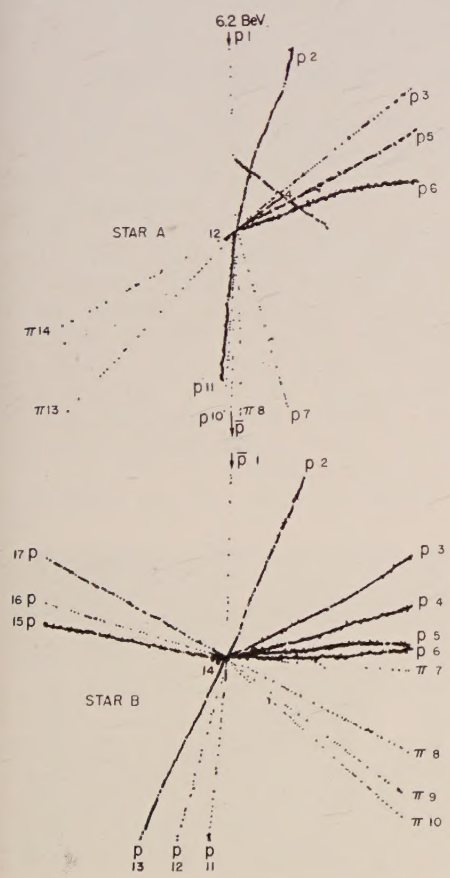
The "Why" of Things . . .

RESEARCH IN PHYSICS

at the University of Illinois

by Jim Kries, Eng. Physics '59

A casual stroll through the Physics buildings would never reveal the great amount of research currently being carried on at Illinois. Behind those unimpressive doors marked "Research Laboratory" is some very impressive and valuable research. Milestones are reached and passed with little fanfare and very little awareness by the student engineer. Most of the research, however, may well affect each and every one of us some time in the future.



The track of anti-protons is followed on this photo-chart

Research in physics is aimed toward one general goal: obtaining information about natural phenomena of all types and classifying those data by formula and theory. Most of the current activity is in the field of modern physics, concerned with neutrons, protons, electrons; gamma rays, alpha and beta particles; and the many other particles and radiations of the nuclear system.

Let us just quickly review those fundamental principles you knew at one time and probably forgot right after the exam (or was it during the exam?). The stable atom consists of a nucleus surrounded by a number of electrons in orbits surrounding the nucleus. The primary constituents of this nucleus are protons and neutrons. When left "undisturbed," this represents a fairly accurate picture of the situation. However, when these nuclei are bombarded with alpha particles, beta neutron particles, or gamma radiation; subjected to low temperature or placed in a strong electromagnetic field, strange things occur. Investigating these "strange things" is the current activity of a large portion of physics research.

STRANGE PARTICLES

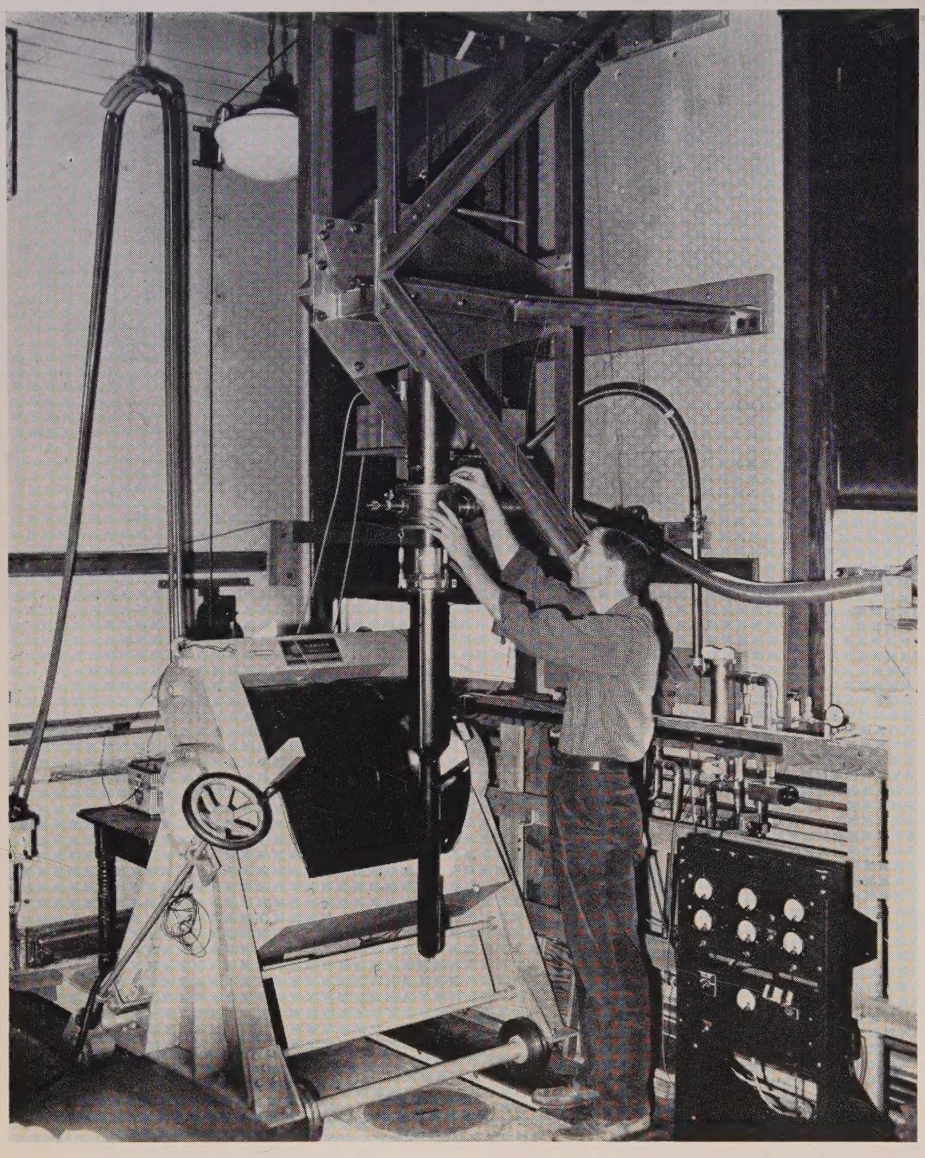
One group, under Dr. R. D. Hill, is investigating the creation of "strange" or "curious" particles by high energy radiation. The source of this radiation is the Berkeley Bevatron of the University of California. In a photographic emulsion the creation and subsequent annihilation of one of these strange particles, the antiprotron is found. The antiproton is created in Star A and follows track 9 until it is annihilated in Star B.

Besides the antiproton, some other curious particles discovered to date include *L Mesons* and *K Mesons* whose mass are between those of the proton (or neutron) and the electron, also included are the *Hyperons* whose masses are greater than the proton. When more energetic radiation equipment becomes available, perhaps even more particles will be uncovered. In the meantime, Dr. Hill's group is busy cataloging these particles and trying to uncover physical laws to explain the existence of the "strange particles."

MAGNETIC RESONANCE

Like many other physical objects such as organ pipes, radio turning circuits, and radar "plumbing," nuclei also have a resonance whose frequency is determined by the strength of the magnetic field it is in and the magnetic moment (strength of the nucleus as a magnet) divided by the angular momentum of the spinning nucleus. (These spin in a manner analogous to the way the earth spins on its axis every 24 hours.) Search coils surrounding the nuclei have an EMF (voltage) induced into them caused by the gyroscopic motion of the atomic nuclei magnetic moments in the magnetic field.

Perhaps the first experiments in this area concerned the measurement of magnetic moments and angular momentum of various nuclei unknowns and relating them to the physical layout of the nucleus. Since nuclei are found in all matter, they may be thought of as probes built into all substances by nature. Through nuclear magnetic resonance, one may therefore probe the inside of solid materials without in any way dis-



VERY LOW TEMPERATURES ARE measured with the aid of this device

turbing the substance under investigation. Another big project is adapting this procedure by the National Bureau of Standards' usage since this method shows the most accurate measure of magnetic intensity yet found. Other investigations include the measurement of magnetic strength of electrons in what are ordinarily non-magnetic metals, the rate at which atoms move around in some solids; investigating the structure of imperfect crystals, the atomic structure of photography, the polarization of nuclei; and the verification of certain aspects of superconductivity theory.

VERY LOW TEMPERATURES

A well-known physical law states that molecular activity decreases greatly with a drop in temperature. It would seem that if molecules could be cooled sufficiently, they would exhibit properties previously masked by thermal agitation. A group under Dr. J. S. Wheatley has attained temperatures as low as 0.003 degrees Kelvin. At such low temperature, nuclear effects may be observed. In their apparatus, the paramagnetic sample under observation is placed in special Dewar "thermos bottles." These Dewar flasks surround the sample with a "refrigerator" consisting of a layer of liquid helium (boling point 4 degrees K) which is itself surrounded by a layer of liquid nitrogen (b.p. 77 degrees K). These layers are kept separated from each other and from the outside by a vacuum layer as in the ordinary thermos bottle.

The liquid helium is cooled to about one degree by lowering its vapor pressure. The whole system is then placed in a magnetic field. The magnetic field "lines up" the atomic magnets in the sample, causing it to give off heat. This heat is carried off the liquid helium by low pressure helium gas surrounding the sample. When thermal equilibrium is reached, the helium gas is pumped off and the magnet removed. The sample then cools down since it has been thermally isolated from the surrounding helium bath. Through this adiabatic demagnetization extremely low temperatures may be obtained.

THE CYCLOTRON

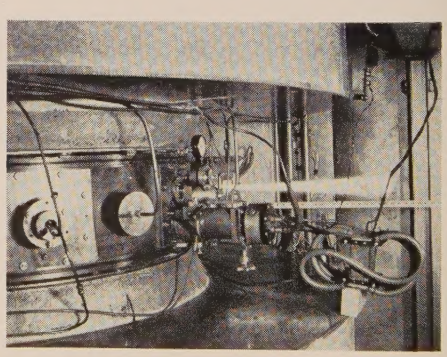
Dr. J. S. Allen remarked that the enlargement of the cyclotron facilities will eventually enable research in that machine to become much more versatile. Since Prof. G. P. Kruger built the cyclotron in 1944, it has had no major rebuilding until this present project. When the program is completed, the energy of the accelerated particles can then be varied by a factor of two or three to obtain further information about nuclear reactions. The original machine had a fixed energy level: 12 Mev (million electron volts) for heavy hydrogen nuclei, 6 Mev for light (ordinary) hydrogen nuclei, and 24 Mev for helium nuclei.

The cyclotron is used in studies of the disintegration of various atoms bombarded by these high energy particles. In these studies, cloud chambers, geiger counters, scintillation counters, etc., will be used to study the behavior of the various types of particles which appear when an atom disintegrates. Dr. Allen summarized his activities by saying: "As in most investigations of the nuclear physics, our goal has been and still is the establishment of the relations which describe the fundamental forces existing between the various particles of modern physics."

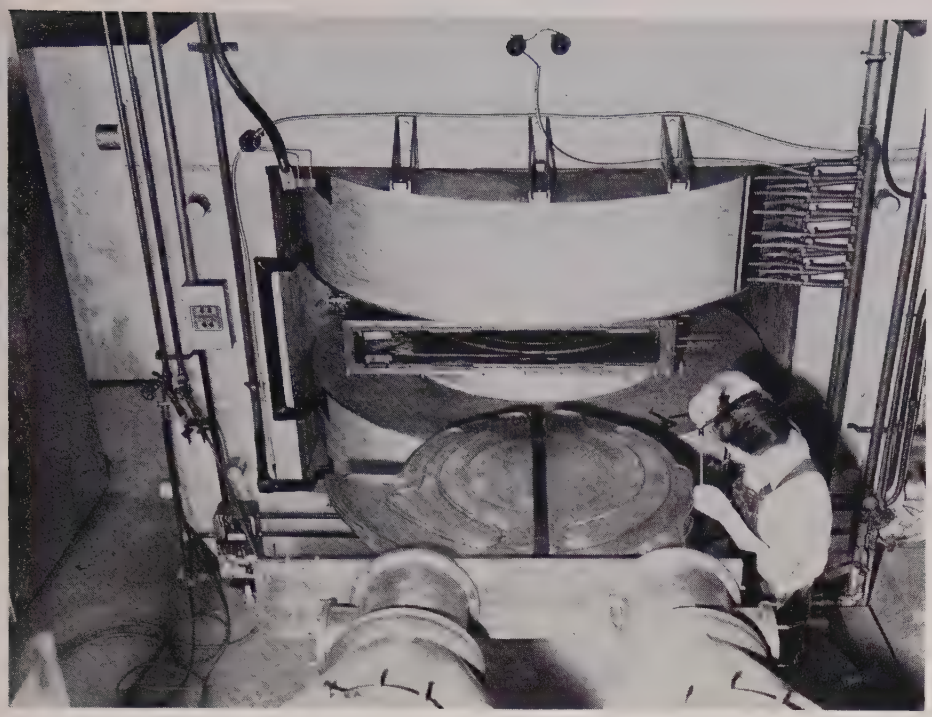
SEMICONDUCTORS

Recent news stories have added glamour to one field of research—semiconductors. Hoping to clear up many of the mysteries still remaining, an experimental group in the E. E. Semiconductor Research Lab under Dr. John Bardeen are doing extensive research in three areas: learning more about the diffusion process in semiconductors; using diffusion as a means of altering the electrical characteristics, particularly at the surface; and studying the effect of large electric fields on electron conduction.

Diffusion occurs in semiconductors



Side view of beams emerging from Cyclotron



THE "DEES" OF THE CYCLOTRON are exposed in this view

through two types of impurities, substitutional and interstitial. In the substitutional impurities (in which some element replaces germanium or silicon in the crystal lattice), diffusion takes place through thermal imperfections such as vacancies. Other elements such as lithium, copper and nickel diffuse by hopping from one intersitial position (space *between* the germanium or silicon atoms in the lattice) to some other interstitial position. It is hoped that these experiments will lead to an understanding of the nature of the semiconductor may be explained in terms of classical (or modern) physical theory.

Surfaces seem to hold much of the mystery of semiconductors. One program, nearing completion, concerns the location and density of surface states on etched germanium and silicon surfaces. Another concerns the alteration of the surface either by bombardment or diffusion of impurities. The third is a study of physical properties of the clean germanium surface in ultra-high vacuum. This latter program has been extremely useful since it has shown that surface states can be intrinsic to the germanium surface and are not necessarily due to chemical impurities or imperfections.

Besides its importance for its own sake, knowledge about semiconductors is of great value to industry towards perfecting the transistor for widespread commercial usage. It is felt that many problems now occuring in transistor manufacture and application can be more easily understood once the fundamental nature of semiconductors is fully understood.

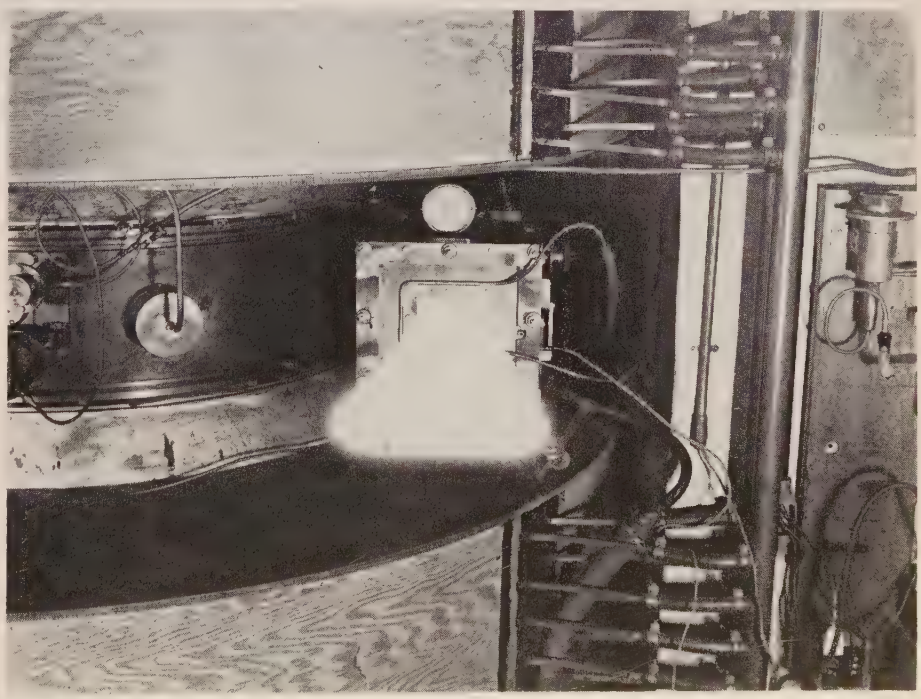
SUPERCONDUCTIVITY

We've all heard of the freezing and boiling of materials; we all know, for example, that water freezes at 32°F, and boils (at atmospheric pressure) at 212°F. These are familiar examples of changes of state. More mysterious, however, is the electronic change from the normal to the superconducting state which occurs in certain metals at temperatures below —439°F (about 11°K). At least twenty-two different elements (and a larger number of alloys or compounds) have been found to make such a low temperature transition and are known as superconductors.

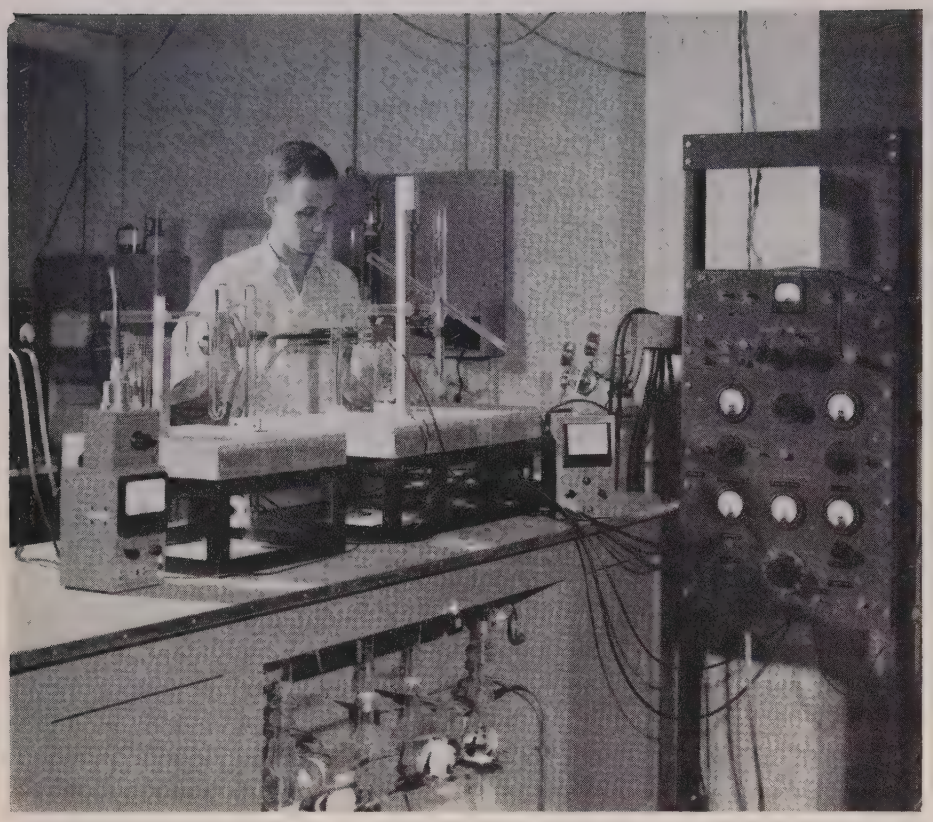
Among other striking properties, the superconducting state is characterized an apparently total loss of electrical resistance. A current initiated in a loop of superconducting wire will circulate undiminished for an indefinite period without any source of emf, so long as the loop is kept below the transition temperature. Such persistent currents, as they are known, have been reported to circulate without detectable decrease for periods up to one and half years. It is also interesting and suggestive that the superconducting elements are those metals having relatively poor electrical conductivity at normal temperatures. The best electrical conductors at normal temperatures, copper, silver, and gold, have been tested at temperatures as low as 0.05°K and they do not show superconductivity.

The research at Illinois, in addition to seeking information about the characteristics of the superconducting state, is directed toward an understanding of why it occurs in terms of the atomic structure. Nobel prize winner, Prof. John Bardeen of Illinois, and Prof. Prohlich of England have independently developed theories in recent years which show promise of explaining superconductivity in terms of a fundamental atomic theory. These theories are now being tested.

One characteristic of the superconducting transformation is that the transition temperature decreases as the magnetic field at the specimen increases. An experimental group under Dr. D. E. Mapother is engaged in making precise determinations of the relation between



FRONT VIEW OF EMISSION from the Cyclotron



IONIC CRYSTAL FORMATION is an important part of physics and chemistry

the magnetic field and the trnsition temperature. This relation is altered by such physical changes in the specimen as variation of the average isotopic mass or the application of hydrostatic pressure, and measurements of both eqects are now being made. "The real point of our research," says Dr. Mapother, "is understanding, from a fundamental point of view, why superconductivity occurs."

SURFACE PHYSICS

Something relatively new in research is the investigations of surfaces. Everything in our universe has surfaces, thus it seems only natural to study why these surfaces exist as they do and what peculiar characteristics they possess. One approach to the problem is being taken by a group under Dr. H. Frauenfelder. Using ultra-high vacuum and radioactive tracers, they hope to obtain information about these peculiar things called surfaces.

In their research, the sample under consideration (usually a metal) is thoroughly cleaned in a vacuum (the pressure is approximately 10^{-11} mm of mercury cury) in order that the surface is not quickly covered with gaseous molecules from the air. With the aid of radioactive material and scintillation counters, they are determining the temperature necessary for the radioactive atoms to leave the surface. Other measurements the group hopes to make include the depth of penetration of a magnetic field in a superconductor and the electric field gradients on metal surfaces. Although the work presently being carried on is of a preliminary nature, it would appear at this stage to be a very informative and valuable type of research.

IONIC CRYSTALS

Most of us have heard of ionic crystals in some chemistry course; all of us use them daily. Basically these crystalline forms occur when the excess electrons in the orbit of one element fill in the deficiency in another element's orbit. These two elements are then held together in the lattice by the Coulombic forces of electrostatic attraction. Common examples of ionic crystals include sodium chloride (table salt), silver chloride, and silver bromide. Electrical and optical properties of these typical crystals are currently being investigated by a research group under Dr. R. J. Maurer.

In the formation of these crystal lattices, certain defects occur. One of these is a *vacancy*. This is simply a place where there should be an ion but none is present. If there is one sodium missing, for example, an adjacent sodium may move into the vacancy, thus displacing the vacancy. Another ion might tend to go into the vacancy, and thus an ionic current is formed. This *diffusion* can be measured by introducing radioactive sodium into the lattice in one layer, allowing the diffusion to continue for some time, then slicing the crystal into very thin layers and measuring the amount of radioactive sodium present in each layer. Using this technique, the effects of temperature and pressure on the lattice can be studied.

When light strikes a crystal another type of current is initiated. Light energy striking a chlorine ion releases an electron. These electrons do not get very far in the lattice as they are soon trapped. One thing the research group is studying is the nature of these traps: what couses them, how they function specifically, and what effect they have on the physical properties of the crystal. It has been discovered, for example, that these trapped electrons impart color to sodium chloride. Similar effects are obtained with the silver chloride crystals.

The photoelectric effect in silver halide crystals makes these substances the foundation of the photographic industry.

THEORETICAL PHYSICS

The foundation of all physics depends on the theoretical physicist providing the "whys" to a problem. Here at Illinois we are privileged to have a number of excellent theoretical physicists including Dr. Bardeen, Dr. Seitz, Dr. Chew, Dr. Low, Dr. Weneser, and Dr. Nordsiek. Space does not permit any sort of complete description of their activities, but one area previously discussed might be mentioned as an example.

In addition to the following up work in the theoretical aspects of semiconductors, for which he won the Nobel Prize, Dr. John Bardeen is currently interested in explaining superconductivity phenomena. If the rare earths are excluded, about half of the metals and a great number of alloys become superconducting at very low temperatures. Much experimental data have been assembled, yet no explanation based on correctly accepted atomic theory has yet been found and tested that would fully explain this unusual phenomena. Dr. Bardeen and his associates are currently attempting to formulate a theory (based on quantum theory) that will explain superconductivity in terms of the interaction between lattice vibrations and electrons. This work will solve a problem that has been puzzling scientists for the past 50 years.

Much has yet to be covered in the way of research. No mention was made of the Betatron, for example. Even though this report is not completely comprehensive, it should serve as an introduction to the Physics department here at Illinois. During Open House, be sure to visit the betatron, cyclotron, and the other exhibits and find out more about what's going on here at your school.

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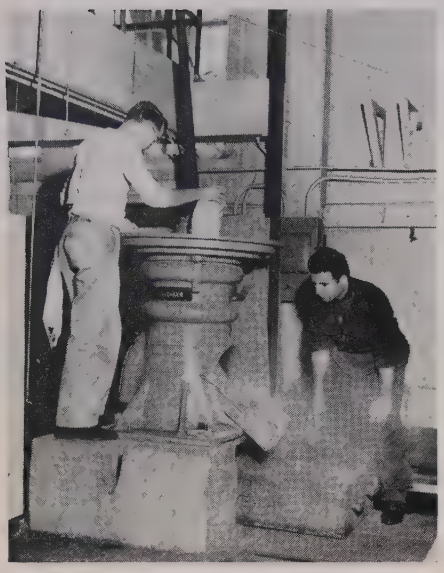


Heating the ore samples

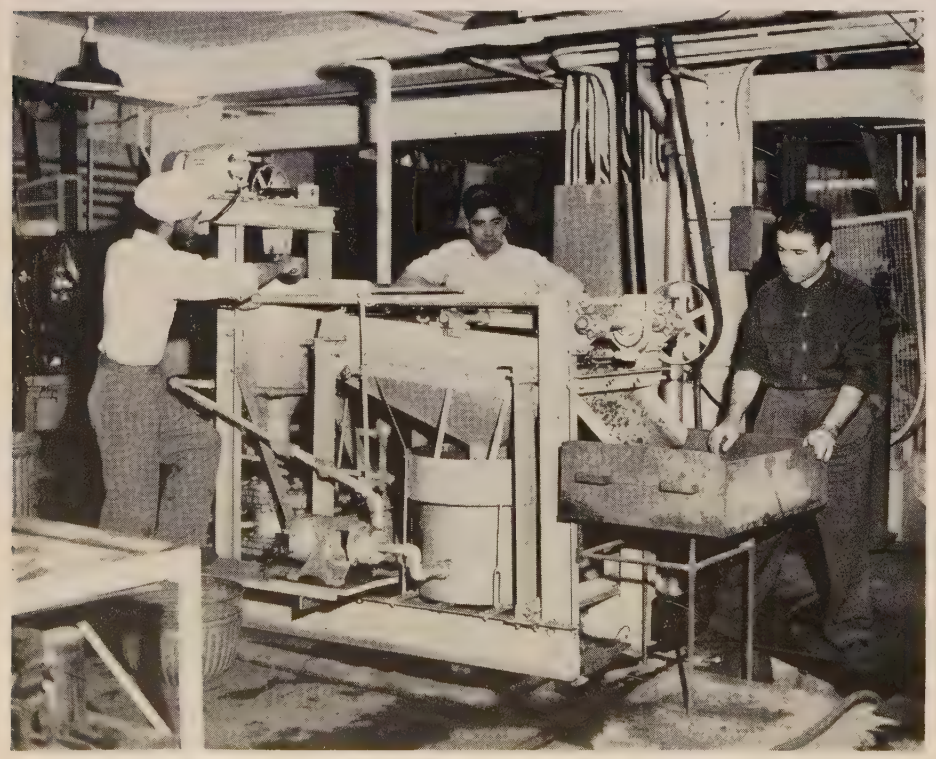
Mining and Metallurgy

by Don Georgi, E.E. '59

Hidden away in back of the Transportation Building and on the third floor of the Ceramics Building are the nuclei of the Mining and Metallurgical Engineering department on our campus. In addition to being tucked away in a corner of the engineering campus, these two types of engineering are all too often forgotten in the publicity drive for engineers. Actually though, these fields offer great challenges for engineers with various goals. Let us take a look at these two types of engineering as the student sees them, and as industry sees them.

In the process of robbing Mother Nature of her store of elements and compounds, the mining engineer has the problem of successfully and safely getting the raw material out of the ground.

The first job in extracting these materials is that of finding the deposits. In addition to the first job, the mining engineer is concerned with exploring and evaluating the find. If the find is valuable enough to mine, the next obstacle is that of extracting, recovering, and treating the material. Before the product is finally shipped, the mining engineer must supervise the whole mining procedure so that it is a profitable and safe operation.



ORES ARE SCREENED IN THIS PROCESS (photos by Dave Yates)

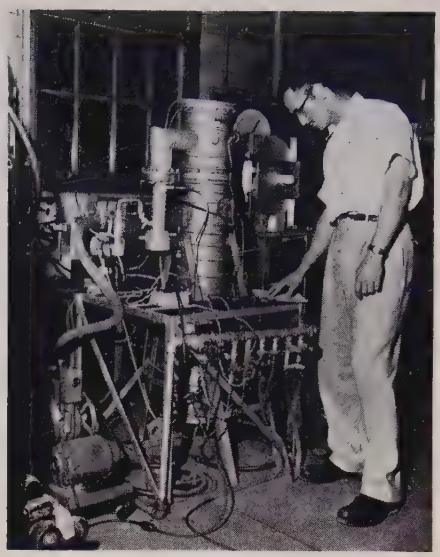
This is the basic work involved in mining engineering, but it is by no means the only work. Many mining graduates find administrative or marketing opportunities waiting for them in the industrial world. More theoretical work in the use of explosives or new mining procedures helps the industry keep abreast of the increased demand placed upon it.

Surprisingly enough, the field of coal mining still offers one of the greatest opportunities for the mining engineer. It is estimated that soft coal production will have to increase by one and one-half times before 1970.

In stride with the increasing demands for mining engineers, Illinois is offering complete training for both the undergraduate, and graduate mining engineer. The undergraduate curriculum has the basic engineering courses, which include mathematics, chemistry, and physics. Later the student probes the fields of electrical engineering and theoretical and applied mechanics, so that combined with his mining education, the student is able to successfully cope with the problems which will arise in his work. Examples of the mining courses would include such things as mineral dressing, in which crushing, grinding, and the sampling of ores is presented, or mining design which is intended to teach the student the principles of head frame construction, shaft stations, trestles, etc. Such courses as design of underground mines and Re-

Two little-publicized fields flourish at the University of Illinois

and Phil Hicks, L.A.S. '59



A student checks analysis of a metal

search in Mining Engineering and Mineral Dressing are for the graduate student working on his master's or doctor's degree.

The only option offered in the mining engineering undergraduate curriculum is that of Petroleum Production. In this option a greater emphasis is placed on chemistry, and of course petroleum production.

Examples of the work done by the mining department at the University, will be on display in the Mining and Ceramics buildings during Engineering Open House.

Closely related to the Mining Engineering curriculum is that of Metallurgical Engineering. Once the ore is successfully out of the ground, it is the job of the Metallurgical Engineer to process these ores so that they meet the requirements of industry.

The metallurgist is classified as either extractive or physical. Let us first discuss the not so obvious title of "extractive."

With the ore at hand, the extractive metallurgist is concerned with extracting the metal from the ore. This job requires utilization of any one or all of five chemical solutions and electricity. After extraction, however, the job is still not done. The metal must be refined. Impurities must be removed and possibly some other materials added. The metallurgists' headaches being from the minute someone decides to use the ore. His problems range from what kind of heat to use in the furnaces to what the furnaces should be made of and what the cost of producing the product will be. Mainly, the metallurgist is concerned with production.

The title "physical" is fairly obvious in meaning. The physical metallurgist is concerned with the physical properties of the refined product. In other words, the question is here a matter of just how the finished product can be expected to perform. Other divisions of the physical metallurgist are concerned with such things as melting, alloying, rolling, forging, treating, finishing, welding, and metallography. (The examination of internal structures of the metal). What does Illinois offer in this field?

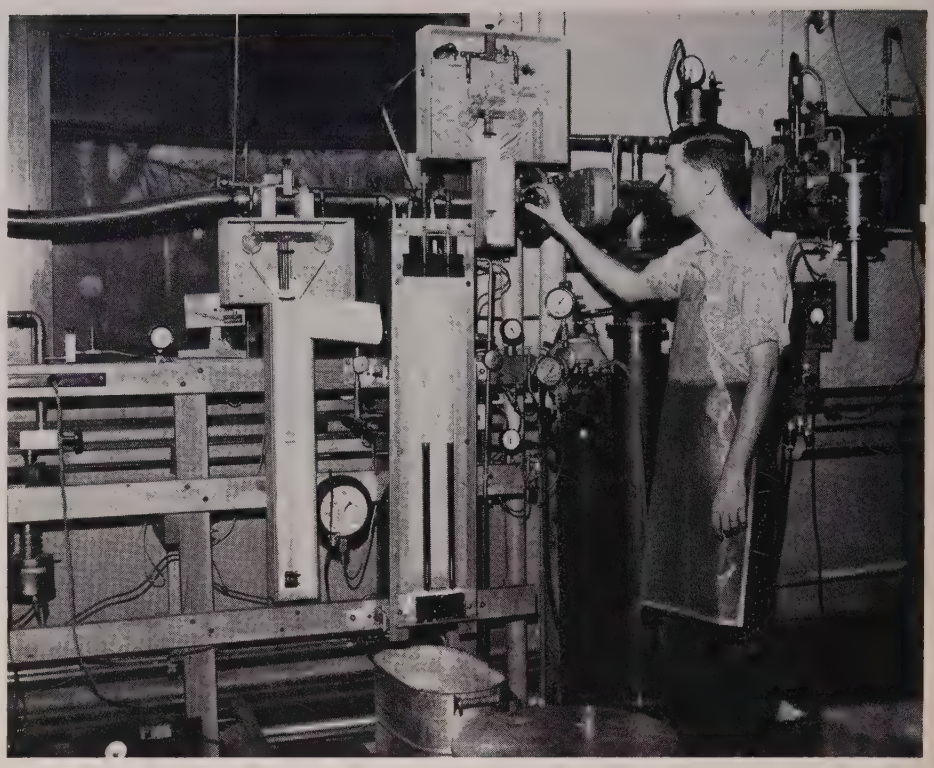
Illinois offers a complete program in metallurgy. However, the hard facts are that the needs of industry for metallurgists have increased, but enrollment has been fairly stable. The metallurgical program has suffered from the popularity of the more advertised fields of nuclear development and electronics. Along with industry's task of creating the demand for potential metallurgists, Illinois is expanding its training program. The undergraduate program is four years long and includes exposure to

METALS MUST UNDERGO SPECIAL HEAT treatment during analysis

chemistry, physics and allied courses.

To further expand the program, the department has been carrying on much research to attract students and especially those students on the graduate level. Since 1950, the enrollment of graduates in the field has more than tripled.

In both mining and metallurgy, great strides are being made to meet industry's demand. One cannot do justice to the fields at this time, but futher and more complete information can be obtained from the respective departments. The important fact is that the demand is increasing in both of these fields and poplarity contests in the engineering fields is obscuring the opportunities possible in the fields discussed here. Look around and ask yourself how much of your everyday life depends on mining and metallurgy.



COMPLICATED INSTRUMENTS ARE REQUIRED in metal processing

Nuclear Warning System

A low-cost electronic system that detects and protects underground facilities against an atomic attack has been developed by the Army Signal Corps, reports *Electronics,* McGraw-Hill publication. When it detects an atomic bomb explosion that would endanger an installation, the system trips relays that instantly sound warning horns, closes blast doors, turns off gas lines, starts radiologically - filtered ventilation systems and triggers a series of other protective measures. The system is already at work at one large military headquarters, and further installations are planned at U. S. Air Force bases, in strategic locations throughout the country.

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Mr. Eltinge earned his B.S. in mechanical engineering at Purdue in 1947. He is a member of SAE, Tau Beta Pi, Sigma Tau, and Pi Tau Sigma. Along with the important contributions he makes to Standard as a regular member of our team, he finds time to attend Illinois Institute of Technology where he recently received his M.S., and takes an active interest in church work.

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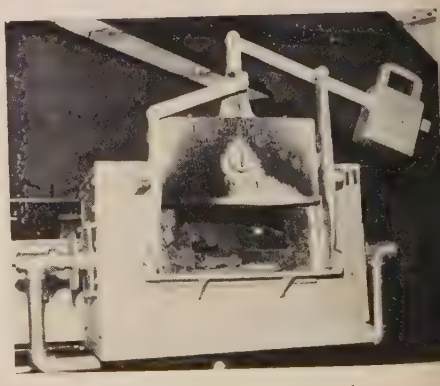
STANDARD

Foundry to Machine Shop

MOLTEN METAL IS POURED INTO prepared molds

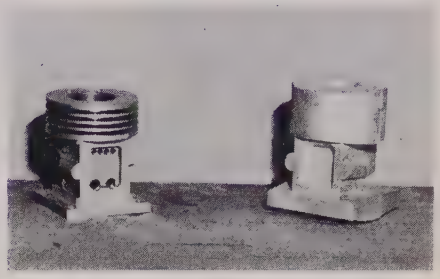
Sand is sifted before casting

SAND MUST BE CAREFULLY packed before pouring of the metal



Metals are heat treated in this over

a photo story by Dave Yates, E.E. '60



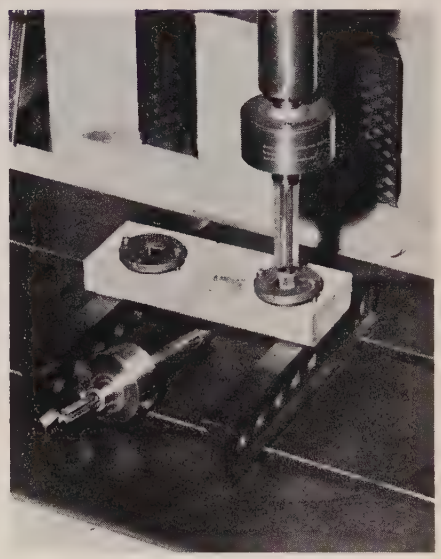
Engine block from rough casting

When a casual visitor wanders in the west door of the Foundry Building from Burrill St., he is sure he has made a wrong turn somewhere. For rather than furnaces and sand and molds, he sees students zealously sawing, planing and shaping wood chairs, tables and what-have-yous. The west end of the Foundry Building is given over to the Woodshop where students in industrial design and occupational therapy, among others, learn how to work with wood.

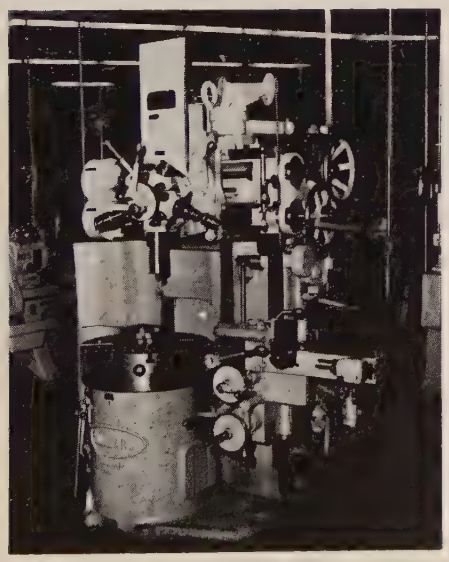
Going east through the building one passes through to the Foundry itself, under the superivsion of Assoc. Prof. James Leach. Here sand is shoveled and sifted to cover molds. The metal, be it alumnium or cast iron is heated in an insulated oven and is poured into the molds.

Some of these castings are for ¾ hp gas engine blocks that are worked on in the Mechanical Engineering Machine Shop. In this fully equipped shop, engine parts are constructed from casting to finish. Students make all parts for the engine including cylinders.

In preparing an engine block, 23 steps including drilling rough and fine boring, finishing and milling are required with square drills, vertical drills and other apparatus. The finished product is shown in the accompanying picture compared to the rough casting.



Ever see a square drill?



This press is not for kiddies

Smaller molds are taken

The finished engine

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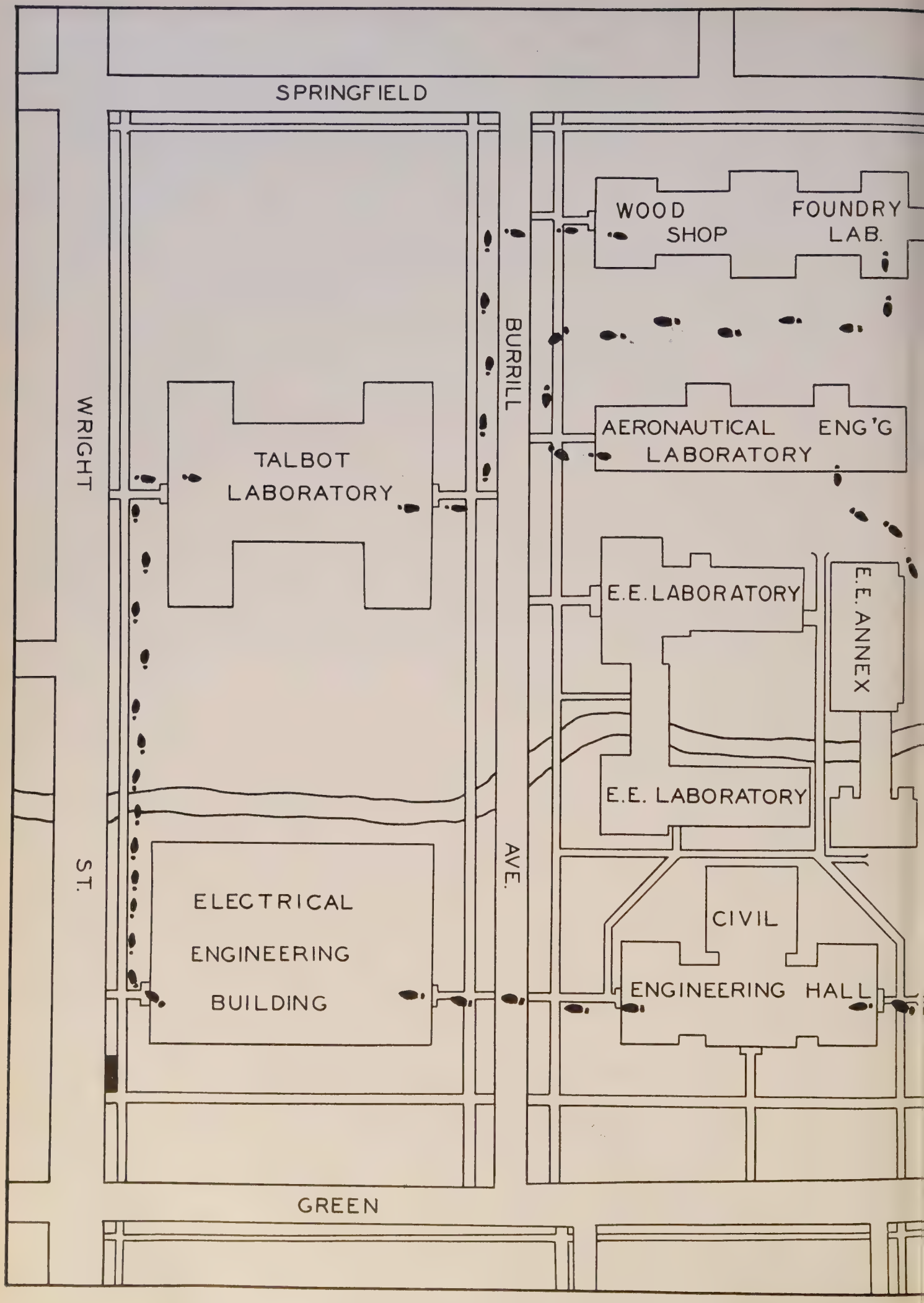
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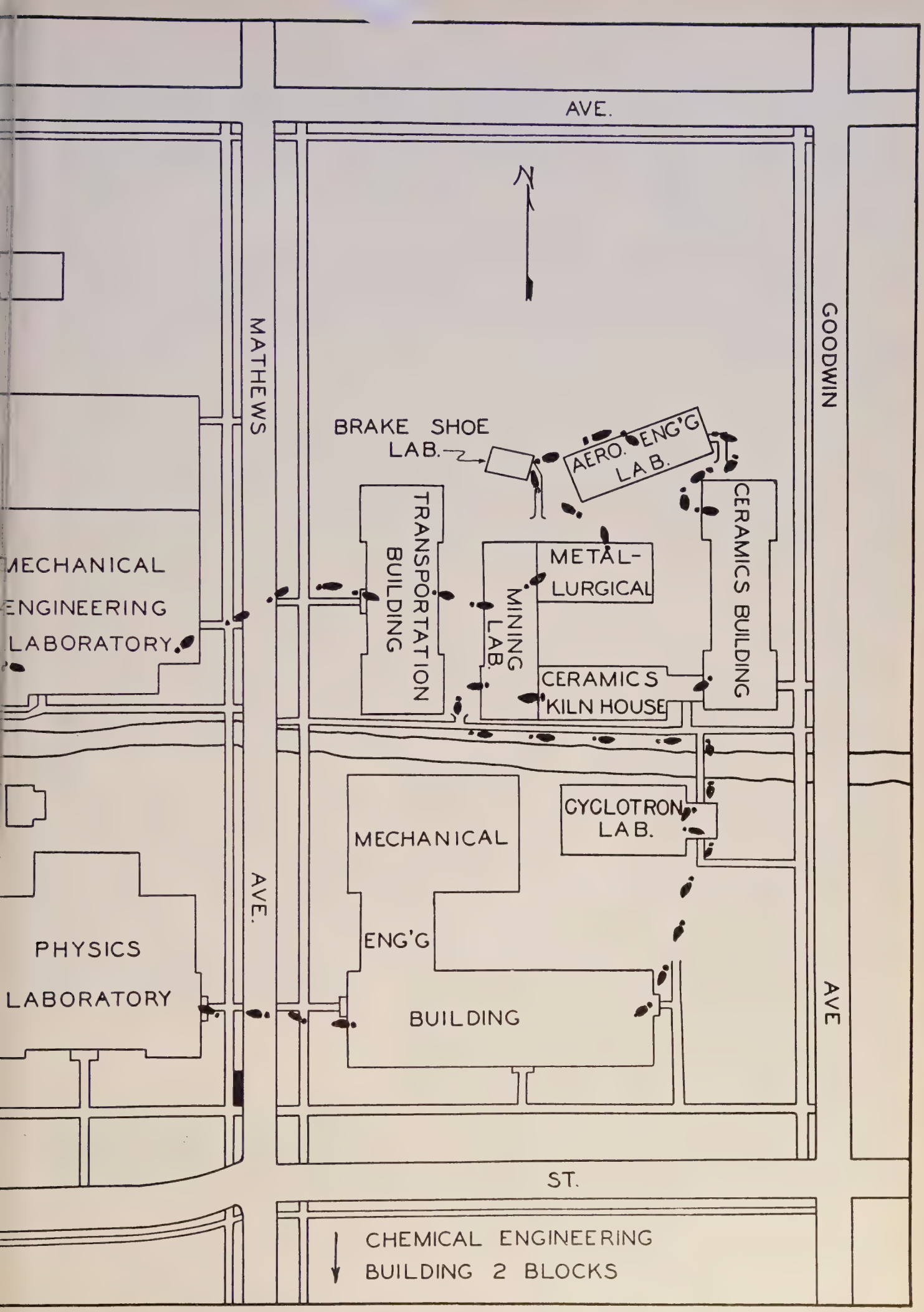
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CERAMICS BUILDING
CERAMICS KILN HOUSE
MECHANICAL ENGINEERING LABORATORY
CYCLOTRON LAB.
MECHANICAL ENG'G BUILDING
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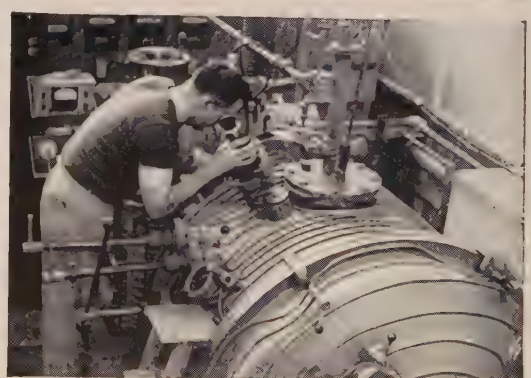
CHEMICAL ENGINEERING BUILDING 2 BLOCKS

What's doing...



Vacuum melting has opened up new horizons for development of alloys. Here, a Pratt & Whitney Aircraft metallurgist is shown as he supervises preparation of an experimental high-strength nickel-base alloy, melted and cast under high vacuum.

Induction melted heat of high-temperature alloy being poured in P & W A's experimental foundry. Molten metal is strained into large water tank, forming metal shot which is remelted and cast into test specimens and experimental parts. Development and evaluation of improved high-temperature alloys for advanced jet engines is one of the challenges facing metallurgists at P & W A.

at Pratt & Whitney Aircraft in the field of Materials Engineering

The development of more advanced, far more powerful aircraft engines depends to a high degree on the development of new and improved materials and methods of processing them. Such materials and methods, of course, are particularly important in the nuclear field.

At Pratt & Whitney Aircraft, the physical, metallurgical, chemical and mechanical properties of each new material are studied in minute detail, compared with properties of known materials, then carefully analyzed and evaluated according to their potential usefulness in aircraft engine application.

The nuclear physics of reactor materials as well as penetration and effects of radiation on matter are important aspects of the nuclear reactor program now under way at P & W A. Stress analysis by strain gage and X-ray diffraction is another notable phase of investigation.

In the metallurgical field, materials work involves studies of corrosion resistance, high-temperature mechanical and physical properties of metals and alloys, and fabrication techniques.

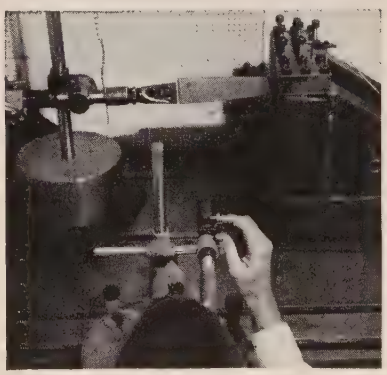
Mechanical-testing work delves into design and supervision of test equipment to evaluate fatigue, wear, and elevated-temperature strength of materials. It also involves determination of the influence of part design on these properties.

In the field of chemistry, investigations are made of fuels, high-temperature lubricants, elastomeric compounds, electro-chemical and organic coatings. Inorganic substances, too, must be prepared and their properties determined.

While materials engineering assignments, themselves, involve different types of engineering talent, the field is only one of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of mechanical design, aerodynamics, combustion and instrumentation — spells out a gratifying future for many of today's engineering students.

Engineer measures residual stress in a compressor blade non-destructively, using X-ray diffraction. Stress analysis plays important part in developing advanced aircraft engine designs.

The important effects of gases on the properties of metals have been increasingly recognized. Pratt & Whitney chemists are shown setting up apparatus to determine gas content of materials such as titanium alloys.



P & W A engineer uses air jet to vibrate compressor blade at its natural frequency, measuring amplitude with a cathetometer. Similar fatigue tests use electromagnetic excitation.

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Jet Reverse Thrust

by Fred Breuer, Aero E. '57

The high landing speeds of modern planes demands some positive means to reduce the landing roll within the limits of today's runways. The reversible pitch propeller provided this control for piston engine airplanes. A comparable device was needed for jet powered aircraft.

Best of the proposed solutions to the problem is the jet thrust reverser which obtains braking force from the exhaust of a jet engine. This study concerns some of the designs and configurations which have been tested and are being perfected into useful and necessary complements to the jet powered craft of present day aviation.

The advent of high speed aircraft brought with it the problems associated with high landing speeds. Obviously a solution could not be obtained by indefinitely extending runway lengths; instead means had to be found to reduce the runway requirements of the aircraft. Wheel brakes have long been used to reduce landing roll but their effectiveness is restricted to dry runway conditions. Since modern aircraft, both commercial and military, must have all-weather capability, supplementary braking devices are a necessity.

For reciprocating engine planes, the answer was the reversible pitch propeller, which has proven to be quite successful.

For the jet powered airplane a control was needed comparable to that of the reversible pitch propeller. Noteworthy among the means tried was the drag chute used on military planes. A disadvantage of the chute is that its braking effect is a function of airspeed so it must be deployed immediately after touchdown to be of value. It also requires facilities outside of the plane to handle the chute once the plane comes to a halt. Further, it has a bit of the "in event of emergency" flavor and would hardly inspire public confidence in commercial jet airliners.

The logical course, then, was to get braking force from the thrust of the turbojet engine. Several proposals have been made to accomplish this using jet thrust reversal systems. These systems fall into three basic types, (1) target, (2) external and internal cascade rings, and (3) straight cascade blades. Considerable work has been done to investigate the performance and reliability of these thrust reversers.

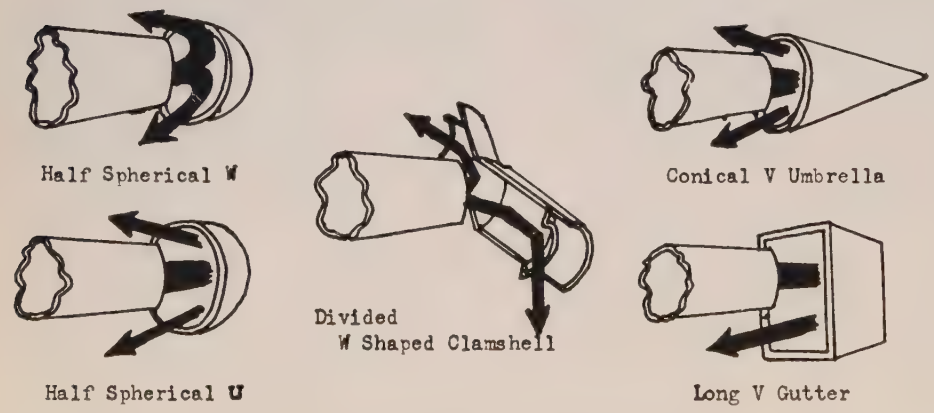

FIG. 1. BOEING JET THRUST REVERSAL SYSTEMS

REQUIREMENTS

Industry seems in agreement on the requirements that must be expected out of any thrust reversal arrangement. These are:

1. The system must be inherently safe and reliable. Electronic controls and intricate protective devices are to be avoided.

2. Mechanical simplicity should be a design objective. Installed weight and stowage space must be kept to a minimum. The thrust reversal unit selected should lend itself to the several engine installations—single pod, double pod, fuselage, and wing.

3. The device should have operational flexibility comparable to present reciprocating engine airplanes with wheel brakes and reversible pitch propellers. This goal can be achieved if wheel braking together with reverse thrust can stop an airplane on an icy runway in the same distance as wheel brakes alone on a dry runway. Calculations indicate that a reverse thrust equal to 40% of the maximum forward thrust will be necessary to fulfill this requirement.

4. The thrust reversal unit should have no effect on engine performance when the reverser is not in operation and should have no adverse effects on the engine when the reverser is in operation.

5. The reversal of thrust should not create any pitching or yawing moments when in operation.

6. The jet exhaust deflected by the reverser must not be deflected against the airplane structure. Furthermore, these hot gases must be kept away from the engine inlet so that the compressor does not draw them in again.

REVERSER TYPES

Target Type

The Boeing Airplane Company began their thrust reverser testing in 1951, concentrating on the target type. They have tried a variety of target shapes (see Fig. 1) to determine the optium configuration for maximum negative thrust with a minimum drag when not in operation.

It was found that the negative thrust obtained from the various shapes tried was a function of the projected frontal area. The V gutter and conical arrangements produced a negative thrust which increased nearly linearly with increases in frontal area. Thrust reversal of approximately 65% was obtained with the largest sizes tested. On the other hand, the half spehrical W, the half spherical U, and the W shaped clamshell gave negative values of thrust which varied only slightly with changes in projected frontal area. The values obtained fell somewhat below the 65% figure. However, all of the shapes produced ample amounts of thrust reversal, so the selection of a best shape could be based on other considerations.

The clamshell configuration best satisfied the various design objectives, excelling particularly in minimum installed weight and minimum stowage space. In addition, the clamshell required the least mounting and actuation mechanisms. The clamshell unit is built in two parts, divided at the center. When not in operation, these two halves are folded for-

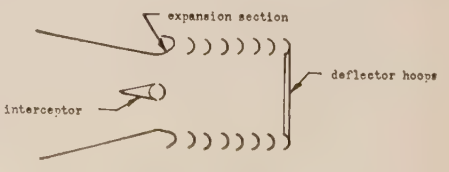

FIG. 2. SNECMA THRUST REVERSER

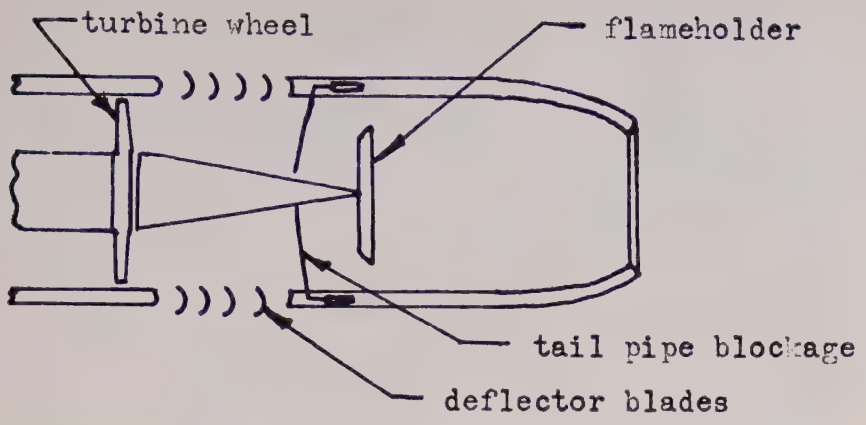

FIG. 3. INTERNAL TAIL PIPE CASCADE REVERSER

ward against the tail pipe of the engine. Their semi-cylindrical shape fits well along the tail pipe, hence practically no drag is added to the airplane. The clamshell especially lends itself to the different engine mountings as it can be easily adapted to single pod, double pod, fighter, and wing installations. The only difficulty anticipated with the clamshell is with afterburner installations having variable tail pipe nozzles. A typical reverser design utilizing the clamshell is expected to weigh about 200 lbs. per engine.

Boeing plans to use its thrust reversers only after touchdown, contending that use for glide path control would increase the probability of reverser failure in flight. They feel that the glide path can be adequately governed by conventional aerodynamic control surfaces.

External and Internal Cascade Rings

SNECMA, the French nationalized aircraft industry, has conducted experiments with a jet deviator using external annular cascade rings with the configuration shown in Fig. 2.

SNECMA bases the operation of their device on the fact that a jet of air, flowing past a convex surface, tends to follow the contour, when suitable obstructions are placed in the jet. In adapting this principle to a turbojet engine, a small expansion section was added to the exit nozzle to provide the convex surface. The jet obstruction was obtained by a mechanical device or small transverse jets of air. With the obstruction in place, part of the jet efflux is deviated into the annular cascade rings which direct this jet forward and thus obtain reverse thrust. When the reverser is not in operation, the obstruction, or interceptor as it is sometimes called, is removed and the jet exhaust passes through the cascade rings without being deviated. Therefore, the interceptor is the only control necessary to put the reverser into operation. As a result, the SNECMA reverser is mechanically simple and should be relatively free from operational malfunction. Actuation of the interceptor requires only a small force and thus allows the pilot to have direct manual control over the reverser. The interceptor may be used in varying degrees which permits reverse thrust to be applied in any amount.

SNECMA requires that their reverser be operatable in flight. Advantages claimed for thrust reversal in flight include steeper glide paths with precision touchdown possibilities, additional maneuverability for military aircraft allowing dive control and opening new avenues for ground attack, and the reduction in size of present landing flaps and air brakes. This last advantage will allow SNECMA to offset the additional weight of the thrust reverser with smaller landing flaps and possible elimination of air brakes. However, flight use will require that the reverser have no effect on the aerodynamic stability of the aircraft.

A license for the SNECMA Jet Deviator has been taken out by the Aerojet-General Corp., Azusa, Calif.

The National Advisory Committee for Aeronautics (NACA) has experimented with an internal tail pipe cascade reverser. This reverser utilizes deflecting blades located in the tail pipe just aft of the turbojet turbine wheel, see Fig. 3. These blades do not completely surround the tail pipe but rather, are mounted in two sides.

To obtain deflection of the jet efflux, the tail pipe aft of the blades must be blocked, at least partially. The tail pipe blockage forces the jet exhaust to pass through the deflecting blades, with a resultant reverse thrust. Since the percentage of tail pipe area blocked can be adjusted between no blockage and full blockage, modulated reverse thrust is available. With the tail pipe completely blocked, NACA got useful values of negative thrust up to 73 per cent of maximum forward thrust. Higher values were obtained but could not be used since they were accompanied by attachment of the reversed jet to the engine cowling which allowed the hot gases to be drawn in again by the compressor. Even so, the 73 per cent value is higher than that produced by any of the other reverser types. Also in favor of the internal reverser is the fact that it appears compatible with the jet exhaust silencers recently announced by Boeing and Rolls Royce.

Two disadvantages of the internal cascade device are that it must operate in the high temperatures and pressures present in the tail pipe and that installation of this unit will necessitate cutting into the basic engine.

Straight Cascade Blades

NACA has tried another cascade blade configuration to obtain jet deviation. In this design straight blades with a cup-like cross section are mounted vertically in the tail pipe of the engine. Reverse thrust is obtained by allowing the tail pipe to split into its two cylindrical side portions, see Fig. 4.

Up to 50% reversal of thrust can be produced with this arrangement, and refinements on the design are expected to raise this value to 60%. The straight cascade blade design is strictly an "on" or "off" reverser as can be noted from Fig. 4; so modulation of reverse thrust cannot be obtained from this configuration.

The biggest disadvantage of this reverser is that the reverser blades are in the jet exhaust when the reverser is not in operation and as a result, approximately 2% of the net forward thrust is lost.

A typical straight cascade blade installation is expected to weigh about 250 lbs. which indicates that this reverser

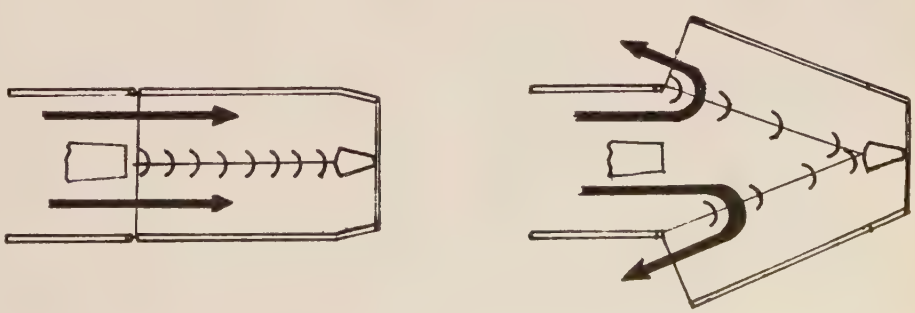

FIG. 4. STRAIGHT CASCADE BLADE REVERSER

can compete favorably with the other types weight-wise.

Experimental results determined from the various reverser types are encouraging. Each of the reverser configurations has shown ample productiton of negative thrust to achieve the braking force desired. Thus it appears that selection of a reverser can be based on other factors such as cost, weight, adaptability of the reverser to the particular installation, need for modulated thrust, and desirability of flight and ground operation or ground operation only.

On safety and reliability considerations, the jet thrust reverser should more than match the level achieved by the reversible pitch propeller, since the jet reverser must function only when in operation while the reversible propeller is unavoidably part of a mechanism that is in use whenever the reciprocating power plants are running.

The cost and complexity of thrust reversal units for future jet aircraft will both be lessened since these planes can be designed and built with the reverser in mind while reversers for present aircraft must be built around the existing structure.

With additional modifications and refinements, "the jet thrust reverser will undoubtedly become the 'pilot's friend' in the near future just as the reversible pitch propeller is today."

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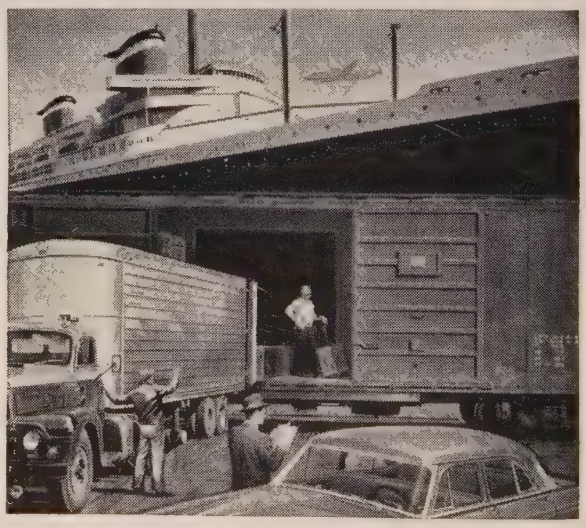

We sometimes become so bemused with its astronomical facts and figures that we are apt to regard the transportation industry as an end in itself.

But transportation has grown into a giant because it represents the translation into reality of some basic precepts of democracy . . . freedom to think, freedom to buy and sell, freedom to move about as we please. The resultant interchange of ideas, people and goods has inevitably led to the development of large-scale, efficient transportation. It is thus no accident that history's greatest democracy should also have history's greatest transportation system to serve it.

The transportation industry itself has never lost sight of its basic origins. Cognizant of its responsibility to the nation, it has always reinvested large amounts of its earnings in plant expansion, in engineering, in research—all for the development of better and more efficient methods, machines and conveyances. That is why American cars, planes, ships and trains are able to supply their services so efficiently and abundantly.

The science of steam generation for power, processing and heating in the transportation industry has likewise kept pace with the demand for greater efficiency. B&W, whose boiler designs power such giant vessels as the *S. S. United States,* continues to invest large amounts of its own earnings in research and engineering to discover better ways to generate steam for ships and trains, for power plants and factories. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

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Dr. Theodore Von Karman

Aeronautical Genius

by Robert C. Ohm, Aero E. '57

Dr. Von Karman

In line with our purpose as a student publication, Technograph tries to publish engineering seminar reports that have a basic interest to the particular field they are written for and for all engineers. The following article is from an Aeronautical Engineering Seminar.

This report was written to acquaint the Aeronautical Engineer with one of his illustrious predecessors—Dr. Theodore von Karman. Because of the innumerable contributions this creative genius has made to Aeronautical engineering and science, he is recognized throughout the world as the Einstein of aviation. As one of the world's foremost aerodynamicists, Dr. von Karman is regarded as the man who has had the greatest influence on the development of supersonic aircraft and guided missiles in the United States. The ability to coordinate theoretical and experimental information into sound solutions of complex engineering problems plus the desire to disseminate these solutions to engineers and scientists in many nations makes Dr. von Karman almost unique in his profession. The Karman double modulus theory of columns, the Karman vortex trail, the Karman similarity theory of turbulence, and the Karman logarithmic velocity distribution and skin friction law for turbulent flow, are typical examples of his keen analysis of complicated phenomena, creation of simplified concepts, and the development of approximate formulae which have been of inestimable value to practicing engineers."

Theodore von Karman was born in Budapest, Hungary, May 11, 1881, His intellect and tastes were undoubtedly acquired from his father, a professor of philosophy and education at the University of Budapest. Young Theodore furthered his early interest in science and technology at the Budapest Royal Technical University and graduated in 1902 with highest honors as a mechanical engineer. He spent the following year in compulsory military service and then returned to his Alma Mater as an assistant professor. In 1904 he accepted a position with the Ganz Company, where he worked as a research engineer on machinery development. The practical engineering experience he obtained here helped develop the positive convictions and straight forward approach to solving problems that he was to use later in his career.

In 1906 he resigned from the Ganz Company and enrolled in the University of Gottingen in Berlin, Germany. He received his Ph.D. degree from this University in 1908 and held the position of Associate Professor until 1912, at which time he was given the opportunity to become Professor of Aeronautics and Mechanics and Director of the newly established Aeronautical Institute of the University of Aachen. World War I interrupted his work here and he was commissioned a Lieutenant in the Austro-Hungarian Aviation Corps. He was assigned as the director of a research department and it was during this time that he designed and built a helicopter with two counter-rotating blades. To this day he maintains that this type of helicopter will eventually prove its superiority.

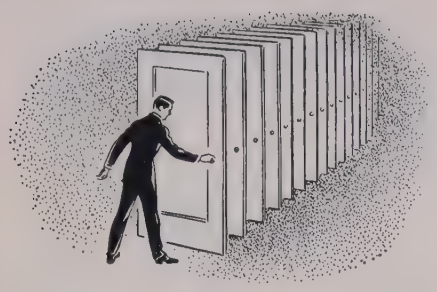
In late 1918 he returned to Aachen to provide the guidance under which this Aeronautical Institute evolved into one of the world's foremost aeronautical research centers. At the same time Dr. von Karman served as a consultant for Junkers, Zeppelin, and other European aircraft companies. His capacity to do so many things at one time and do them well is best explained by Dr. von Karman. He states that Hungarians do impossible things every day. In fact his favorite definition of a Hungarian is "a man who goes into a revolving door behind you and comes out ahead."

In 1926 Dr. von Karman made a trip around the world lecturing at Universities and research centers in Japan, China, India, and the United States. As a result of this trip, he became an advisor to the Kawanishi Airplane Works of Japan in 1927 where he helped build the first Japanese wind tunnel. As another result of his world trip, he became a consultant on the creation and design of the Guggenheim Aeronautical Laboratories and wind tunnel at the California Institute of Technology in 1927 and was appointed Research Associate in 1928. In 1930 he resigned from his position at the University of Aachen to become Director of Technology and Research at the California Institute of Technology. He held this new position until 1949.

From 1930 through 1935 he also directed the Guggenheim Airship Institute at Akron, Ohio, and in 1935 he presented the first theory on supersonic drag. Incidentally, in 1934 he predicted that we would fly aircraft on the other side of the sound barrier and twenty years later the F-100 Super Saber and F4D Skray did fly at supersonic velocities. The formula for the success of these aircraft was given as von Karman plus 3,000,000 engineering man hours equals the fastest.

In 1936 he became a United States citizen and in 1938 he initiated the first Air Force jet propulsion and rocket motor development project. This project was performed at the California Institute of Technology. The next year he became a consultant on the design and development of the first supersonic wind tunnel in the United States. The model supersonic wind tunnel he subsequently developed at the California Institute of Technology pioneered the design and operation of the Aberdeen Supersonic Wind Tunnel.

During his early years in the United States, Dr. von Karman was also engaged in such projects as the study of municipal water pumping in Los Angeles and the design of hydrodynamic systems for Grand Coulee Dam. In 1941 he and two associates were called in to investigate and explain the failure



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of the Tacoma Narrows Bridge in the wind. It was determined that the bridge was structurally stable but not aerodynamically stable or to be precise, the bridge designer had neglected to allow for the Karman Vortex Trail.

His experimental work with rockets and his knowledge of the progress that the top Axis scientists were making with rockets gave Dr. von Karman insight on the importance of rockets as weapons. But when he tried to interest American corporations into producing rockets in 1941, they were too busy manufacturing arms for England, so von Karman decided to produce the rockets himself.

In 1942 Dr. von Karman and four associates, with an investment of $8,700 and five employees, established the Aerojet Engineering Corporation of Azusa, Calif. Within eighteen months Aerojet was producing JATO units for the take off assistance of large planes on short runways or aircraft carriers. Six government loans helped Aerojet expand its facilities and in 1944 the General Tire and Rubber Co. bought up 81% of Aerojet's stock and expanded the plant again.

With the larger facilities Aerojet turned out $10 million worth of JATO units during World War II at $185 a unit, but with the war's end the company experienced a brief downward trend in production. When the B-47 bomber and other large military planes were developed, Aerojet business boomed again and in 1950 Aerojet had a $25 million backlog.

Not enough can be said on the part Dr. von Karman played in establishing and developing Aerojet into the successful rocket producer it is today and in 1943 his interest in rockets and some sketches he made on a Wright Field tablecloth started the thinking on the Bell X-1. Four years later, this aircraft became the first to break the sound barrier.

In 1944, Dr. von Karman resigned his position at Aerojet to become special consultant to Gen. H. H. Arnold and Director of the Army Air Force Scientific Advisory Group. In 1945 he went on a mission abroad to study and evaluate the technical developments in aviation in Germany, Japan and England. It was during this time that Dr. von Karman became associated with the complexities of the Pentagon in Washington, D. C. The following is a parable he likes to tell about his role as an advanced thinker at the Pentagon:

"A centipede, it seems, went to the wise old owl and complained of the gout. Each of its 100 legs hurt. What could it do? . . . The owl thoughtfully advised the centipede to become a mouse. With four legs it would have only 1/25th of its formore amount of pain. The centipede thoughtfully concurred but wanted to know how he could get to be a mouse. "Don't bother me with that," said the owl, "I only create the policy around here."

Between 1940 and 1951 Dr. von Karman was a consultant for the General Electric Co. and the Northrop Aviation Co. In 1946 he presented the first comprehensive theory on supersonic aerodynamics in his book entitled "Aerodynamics" and this book has since been recognized as the "Aerodynamics Bible." In 1947 he wrote another article for the Journal of The Aeronautical Sciences entitled, "Supersonic Aerodynamics — Principles and Application." In this article Dr. von Karman introduced his three rules of supersonic flow which we study in Aerothermodynamics. These rules associated with the Mach Cone are the "Rule of Forbidden Signals, The Zone of Action and the Zone of Silence, and the Rule of Concentrated Action. These rules and the other material presented in this article constitute a paper that was truly a forerunner of the era of supersonic flight. Incidentally, the first issue of the Journal of the Aeronautical Sciences back in 1934 included an article on "Turbulence and Skin Friction" by Theodore von Karman.

In 1952, at the age of 70, Dr. von Karman became chairman of the Advisory Group for Aeronautical Research Development that was set up on his recommendation by the North American Treaty Organization. The function of this group is "to review advances in aeronautical science for application to the defense problems of the Western nations." It has been stated that Dr. von Karman is perhaps the only man alive who can handle this position. His eminence and friendship with everyone in the field of aviation can be best explained by his attitude towards America and European science. "In the United States," he says, "we concentrate on 'know-how.' In Europe they work on 'think-how.' Each needs a little of the other's approach."

His work for NATO takes him all over Europe and the United States and quite naturally he travels by airplane. For all his genius, however, he has never learned to fly an airplane himself.

In March, 1955, Dr. von Karman was engaged by the Convair Division of the General Dynamics Corp., as a consultant on guided missiles and nuclear research. More recently he has done research on space flight beyond the earth's atmosphere where aerodynamic problems proceed to those of the slip-flow region. In this region it is conceivable that a projectile will reach speeds expressed in terms of fractions of the speed of light.

Dr. von Karman is the typical absent-minded professor. He is constantly receiving hats by mail that he had forgotten on his many trips around the world. During World War II he was

followed around by an F.B.I. man who picked up the secret documents that von Karman left in taxis or hotel lobbies. His keen sense of humor and philosophy of life are particularly evident in his driving. A friend once suggested that Dr. von Karman get three smashed fenders fixed. Dr. von Karman said that he would, as soon as he smashed the fourth.

However, this same humorous, absent-minded professor has the ability to speak seven languages fluently. He has written over one hundred articles on subjects such as Applied Mathematics, Physics, Strength of Materials, Elasticity, Plasticity, Monocoque Structures, Vibration Phenomena, Turbulence, Heat Transfer, and Aerodynamics. These articles have been published in approximately ten countries. Dr. von Karman has lectured at the University of Brussels, the University of Cambridge, the Sorbonne in Paris, the Central Aero-Hydrodynamical Institution in Moscow, the National Taing Hua University in China, and many Universities in the United States.

He is a member of the National Academy of Sciences in Washington, D.C., the Royal Society in London, the French Academy of Sciences in Paris, the Royal Academy of Sciences in Italy, the American Society of Mechanical Engineers, the Institute of Aeronautical Sciences, and in 1955 Dr. von Karman was named to the Pontifical Academy of Science by Pope Pius XII.

Dr. von Karman has received many awards, the more notable ones being the John Fritz Medal for 1948, the first Astronautics Award of the American Rocket Society in 1954, and the 1954 Wright Brothers Memorial Trophy, an award that had been previously given to Charles Lindbergh and Gen. James Doolittle.

Dr. von Karman is truly a genius of our time. His pioneer investigations and theory have contributed greatly to the development of aviation and his success in solving the complex problems of turbulent regions, shock waves, and supersonic drag has been our gain. His presence in aviation has been quite pronounced.

REFERENCES

H. L. Dryden and C. B. Millikan, *Supplement to John Fritz Medal Book* (New York, 1948), p. 1.

M. J. Candes, *Current Biographies, 1955* (New York, 1955) pp. 622-624.

"Absent Minded Professor," *Time* (New York, May 21, 1956) pp. 63-64.

"The Air Age's Genius of Speed," *Newsweek* (Dayton, Ohio, December 20, 1954) pp. 80-81.

"Whoosh!" *Time* (New York, January 1, 1951) pp. 56-58.

W. B. Oswald, "Applied Aerodynamics and Flight Mechanics," *Journal of the Aeronautical Sciences* (New York, May, 1956) pp. 469-484.

"The von Karman Award," *Aviation Week* (New York, December 6, 1954) p. 122.

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THE SOCIETY COLUMN

by Don Snedeker, E. E. '58

Guest speaker at AIEE's January 10 meeting, was Mrs. Pauline Chapman, placement office of the College of En-Engineering. Her subject was "Do's and Don't of Job Interviews."

After inviting one and all to see the new facilities of the Engineering Placement Office in 109 C.E.H., Mrs. Chapman told the group that 408 companies planned to interview on campus during the spring semester. Although no exact figures were available, she said this was more than the number of Spring 1957 graduates. Job offers were good, she said, with February grads receiving an average of $460.42 per month.

Mrs. Chapman urged all graduating seniors to complete and turn in their placement data sheets for their own benefit and for the benefit of interviewing firms, as these sheets give basic information on which an interview can be conducted.

Dates for interviews will be published three weeks in advance with times and places being posted one week in advance on the Placement Office bulletin board.

Some hints Mrs. Chapman gave were to know the company you are interviewing, have some idea of what you expect from your job and company. Above all. dress well and not in jeans with slide rule hanging from the belt.

She advised all seniors to keep a file on the companies they interviewed, with company data, letters and other pertinent information.

Once a job is obtained, a senior should notify all other companies of his acceptance, thus releasing them from further obligation to him and vice-versa. She urged that all correspondence from interested firms, be answered immediately so they will know if the senior is interested or not as soon as possible.

After Mrs. Chapman's talk, Hank Tobinski, Engineering Council representative, reported that Buddy Morrow's band had been selected to play at St. Pat's Ball, March 15.

A request was made to keep the Electrical Engineering suggestion box free from such suggestions as giving the answers to E. E. 229 problems and the meeting adjourned for coffee.

COFFEE HOUR

Dean Everitt and Prof. W. Leighton Collins, secretary of the American Society for Engineering Education spoke at the semester's last Engineering Coffee Hour, Jan. 10 on the subject of "Engineering as a Profession."

Dean Everitt, who is also president of ASEE, spoke in detail of the various divisions of the field of engineer and the societies which appeal to these divisions.

The oldest subject matter society is American Society of Civil Engineers, founded in 1852. Next came American Institute of Mining, Metallurgical and Petroleum Engineers, in 1871; American Society of Mechanical Engineers in 1880; and American Institute of Electrical Engineers, found in 1896. These four constitute the so-called Founder Societies.

Closely linked with AIEE is the Institute of Radio Engineers, founded in 1912, which has joint student branches with AIEE.

Other subject matter socities are American Institute of Chemical Engineers—1908; American Institute of Industrial Engineers—1948; Institute of Aeronautical Sciences; National Institute of Ceramic Engineers—1938 and American Society of Agricultural Engineers.

The four founder societies, along with AIChE, in 1940 founded Engineers Joint Council, to give a common voice to engineers in the United States, particularly for advice to government. It was reorganized in 1952 to admit 11 members.

Aside from subject matter societies, there are general institute societies. Some are: National Society of Professional Engineers, which founded in 1934. NSPE is an association of licensed engineers dealing primarily with professional matters.

ASEE was founded in 1893 as a society of engineering educators and industrial people interested in education. There are 7,800 members in ASEE which is now conducting a study of the development of engineering facultites to handle increased enrollments.

In 1934 the National Council of State Boards of Engineering Examiners, Engineering Institute of Canada, ASEE, AIChE, ASCE, AIEE, AIME and ASME formed the Engineers' Council for Professional Development. This group was organized to develop a common accrediting system for engineering colleges to meet needs of growth of licensing of engineers by states.

They now have six major functions directed by corresponding committees:

1. Accreditation.
2. Guidance.
3. Student Development.
4. Recognition.
5. Ethics.
6. Information.

This success of the Fall Semester Coffee Hours, assures members of Engineering Council that such affairs will be held again this semester.

LISLE ROSE AWARD

The first Lisle Abbott Rose Memorial Award will be presented to an engineering senior this spring for outstanding work combining "both" technical excellence with wise selection and unusual achievement in non-professional courses and extra-curricular cultural activities.

The annual award has been established in memory of Dr. L. A. Rose, former University director of engineering publications and information. The winner will receive $100 and his name will be engraved on a permanent plaque.

Any engineering senior who will be graduated in June or August 1957 or February 1958 is eligible for this year's prize.

Each professional department of the College of Engineering will nominate one student for final consideration on the award. Students may be recommended by the departments or apply directly to the award committee.

Departmental representatives in selecting nominees for the award are: H. O. Barthel, aeronautical engineering; E. L. Hansen, agricultural; E. D. Lynch, ceramics; Max Peters, chemical; W. W. Hay, civil, chairman; John Kreer, electrical; C. H. Springer, general; Francis Seyfarth, mechanical and industrial; E. J. Eckel, mining and metallurgy; and E. M. Lyman, physics.

Contributions are still being received for the memorial fund and it has nearly reached its full quota, according to W. W. Hay, chairman of the committee.

"A major part of Mr. Rose's life was dedicated to bettering understanding between liberal arts and sciences and engineering," Hay said.

"In his own person he demonstrated how admirably these aspects of life may be combined."

Dr. Rose himself was trained in the humanities, but early in his teaching career joined the English faculty of the Michigan College of Mining and Technology. There he developed the understanding of engineering student needs which he put to use at Illinois.

He joined the University faculty in 1947. An active member of the Ameri-

can Society for Engineering Education, shortly before his death in 1955 he was appointed editor of the ASEE Journal.

Rose felt that the modern engineer, in addition to professional competence, is required to have broad interests, knowledge, appreciatiton, and skills in nontechnical areas. The Memorial Award criteria have been drawn accordingly.

Finalists will be judged on quality of thought, written and spoken—both in class and out; selection of and success in non-professional courses; extra-curricular activities showing both the depth of interest and comprehension in non-technical fields; and other special or individual contributions.

Members of the original committee are: I. A. Cochrun, representing friends of Mr. Rose in the community; W. Leighton Collins, professor of theoretical and applied mechanics; J. S. Dobrovolny, assistant professor of general engineering; N. H. Manderfield, Michigan College of Mining and Technology; R. J. Martin, associate director of the Engineering Experiment Station; E. C. McClintock, director of engineering information and publications; J. M. McCrimmon, head of the Division of General Studies; S. H. Pierce, associate dean of the College of Engineering; and Allen Weller, dean of Fine and Applied Arts.

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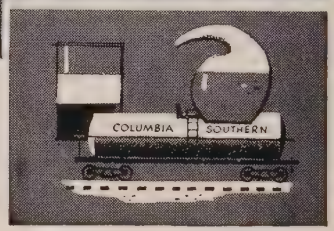
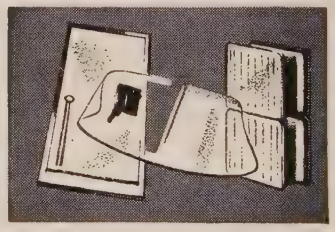
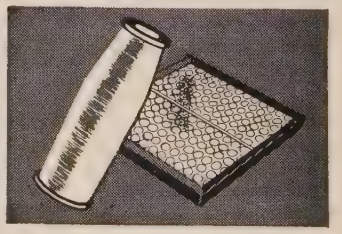


Columbia-Southern Chemical Corporation, a subsidiary of PPG, is a leading producer of industrial chemicals.



PPG produces large quantities of glass for automotive, home building, commercial and industrial uses.



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RCA Electronic Music Synthesizer

by Harry Hirsch, E.E. '57

This being the electronics age, scientists have been intruding into all forms of human life. Electronics was a part of music even before the term "electronics age" was dreamed up, with Hammond organs and electric guitars. Now scientists at the RCA Laboratories have gone whole hog in their production of the Electronic Music Synthesizer.

The electronic music synthesizer is a machine that produces music from a coded record. The coded record is produced by a musician, musical engineer, or composer with a fundamental understanding of the composition of sound. It provides a means for the production of a tone with any frequency, intensity, growth, duration, decay, portamento, timbre, vibrato, variation, and we suppose, aesthetic taste.

If these properties of a tone are specified, the tone can be completely described. The advantage of the electronic music synthesizer is that it can produce new and radical tone complexes for musical satisfaction and gratification. The new system does not displace the artist and musician of today. It does not take the place of talent combined with work. The electronic music synthesizer provides the musician, musical engineer and composer with a new musical tool with no inherent physical limitations.

As long as the synthesizer is used as a tool and not as a toy, the music world seems safe. But let some budding engineer reproduce an electric Elvis Presley or "Mairzey Doats" and RCA can give the infernal machine back to the tube manufacturers.

Music, after all, is called the art of producing pleasing, expressive, or intelligible combinations of tones. Most music is made by the human voice or an instrument in the hands of a musician. The ultimate objective destination of all musical sounds is the human ear. Thus the music is put on paper and played by the musician or spontaneously created by the jazz musician employing human voice or musical instrument and the ear hears these "pleasing, expressive or intelligible sounds."

As with all other natural phenomena, musical sounds can be broken into physical properties. These are frequency, intensity, wave form and time. Yet there are other characteristics, psychological in nature, which make up a musical sound. These are pitch, loudness, timbre and time.

Once described by these characteristics, a sound can be produced electronically. Any musical tone, which can be made by human voice or musical instrument can be reproduced electronically. Indeed, tones which have never been heard can be made.

One of the uses of the synthesizer is for the production of phonograph records. Since in conventional instruments a musician is limited to the fingers, two hands, two feet and two lips separately, or in combination, the synthesizer can go beyond these limitations.

Finicky hi-fi fans are troubled by the rushing of wind in the wind instruments,, bow scratch in the viol family, various clatters and rattles in the plucked and struck string instruments, and mechanism rattle in any instrument in which keys, valves, levers and shafts are used. Aged singer's voices tend to crack at embarrassing moments. These undesirable noises do not exist in the electronic music synthesizer. This may come as somewhat of a blow to these collectors who prize records which include the sound of Louis Armstrong dropping a sheet of music, or an excited drum player dropping his drum sticks. With the advent of the electronic method of the production of musical tones, new musical compositions can be written which take advantage of the superior characteristics of the electronic music synthesizer.

If the properties of a tone are completely specified as above, the tone can be completely described. At this point, a further examination of each characteristic of a tone can be made.

Frequency-Pitch

Frequency of a sound wave is the number of cycles occuring per unit of time. In very low notes, one can almost pick out the cycles by ear, and at high notes, they blend indistinguishably.

Pitch is the psychological counterpart of frequency. It is through pitch that the human ear perceives high or low notes. It depends not only upon frequency, but sound pressure and the wave form. To take advantage of the full frequency range of the human ear, the synthesizer covers the entire frequency range of 30 to 15,000 cycles.

Intensity-Loudness

Sound intensity in a sound field in a specified direction at a point is the sound energy transmitted per unit of time in a specified direction through a unit area normal to this direction at the point.

Loudness is the psychological counterpoint of intensity. It depends upon intensity, frequency and wave form of the stimulus. The synthesizer covers the volume range of 0 to 120 decibels. Below 20 decibels, however, sounds are masked by the noise level which exists in all conventional living rooms, halls and theaters.

Duration

Duration is the length of time that a note persists or lasts without interruption or discontinuity in the sound output. It may be fixed, variable but fixed maximum duration or unlimited. The synthesizer produces all variations of the duration of a tone.

Growth and Decay

Growth of a tone involves time required for the sound to build up to some fraction of its ultimate value. Decay is the time required for the sound to fall to some fraction of original intensity. The synthesizer can produce any desirable growth or decay characteristic on an exponential, linear or other function.

Frequency Glide-Portamento

Portamento is a special case of frequency, growth and decay in which the passage from a tone of one frequency to a tone of another takes place in a continuous glide through all intervening frequencies.

Wave Form-Timbre

A complex sound wave is made up of fundamental frequency and overtones. Timbre is expressed in number, intensity and phase relations of the components. It is an instantaneous cross section of tone. The synthesizer can produce a tone of any spectrum together with means for changing this spectrum during the sounding of the tone.

Low-Frequency Modulation-Vibrato

Vibrato is a term to designate primarily a frequency modulation of a tone. Vibrato is accompanied by amplitude modulation and sometimes a variation in timbre. It is used as an artistic em-

DR. HARRY F. OLSON OF THE DAVID SARNOFF Research Center of RCA, operates the keyboard of the new Electronic Music Synthesizer. The instrument synthesizes familiar sounds and creates an unlimited range of tone variations.

bellishment in the voice and many instruments. Eartha Kitt's singing employs the vibrato quite often. The synthesizer can produce either or both amplitude or frequency modulation of any desired frequency as well as a variation in timbre.

Irregular Deviation

One of the beautiful and artistic characteristics of some types of music is the lack of mechanical quality of the rendition. Specific steps are taken in the synthesizer to keep the result from being too regular or inartistic. The synthesizer is indeed far superior to the performer in obtaining deviation from the regular. It can also be superior for cases where random effects are desired because the results can be made even more random than is possible by human means. By some obscure electronic means, the machine produces irregular results, enough to make a scientist in any other field tear his hair.

Requirements

A coded paper record controls all the functions of the electronic music synthesizer. The output is recorded on a disk record. The coded paper and the phonograph records are driven in synchronism by an interconnecting cable drive.

The first requirement is the generation of a fundamental frequency. The souce consists of twelve electrically driven tuning forks with frequencies corresponding to an octave in the equally tempered scale. They are housed in evacuated chambers to reduce the damping effects which would be introduced by surrounding air.

To reduce number of contacts required to select proper frequency in an octave, a binary coding system is used. Thus any frequency can be selected by means of a relay tree. A punched paper tape record 15 inches wide stores the characteristics. It stores information on frequency, growth and decay, duration, volume, timbre, vibrato, portamento and deviations. Holes are punched in the paper by means of a keyboard system.

Three additional circuit sources in the master control system produce random noise to simulate drums, maracas, tambourines, and string and wind instruments. They can also produce weird and unusual sounds. The source is a hot cathode triode gas tube. Output is amplified by a three-stage RC coupled amplifier.

The tuning fork oscillator covers fundamental frequencies in an octave of the equally tempered scale. Any of eight octaves can be selected by means of three circuits in the master control system. Tubes convert incoming sine waves into those wave forms necessary for harmonics. Frequency discrimination systems handle necessary overtones.

In plucked and struck string instruments as well as percussion instruments, buildup time for a tone is short. The buildup tone for an organ pipe is relatively long. Eight different growth and decay characteristics can be obtained from three circuits in the master control system. Different values of growth and decay can be present in the electrical circuits. By varying the amplification of the push-pull output stage of the control tubes, growth and decay is regulated.

Portamento or continuous glide in frequency from one tone to another of different frequency can be executed by voice, trombone, violin or other instruments. All readers are aware of the wailing wah-ah-ah, the trombone puts forth as it glides.

Glide is accompanied by adjusting the oscillator frequency to the input frequency. If input frequency changes discontinuously, the direct current oscillator changes in a continuous manner providing glide.

For volume control a series of fifteen steps in voltage can be obtained in the push-pull amplifier. The volume control system controls the over-all volume of the tone and may change the volume of a tone during the sounding of that tone.

To control vibrato, frequency, amplitude, or wave-form modulation must be controlled. A hot cathode generates a saw tooth wave and amplification varies in a function which approximates a saw tooth or vibrato tone.

A high and low pass filter system with variable cutoff controls timbe control or overtone structure of a tone. Single harmonics, or groups of harmonics may be accentuated. Employing a chain of amplifiers, each tuned to a different frequency makes it possible to obtain all manner of overtone structures.

The paper record is punched by means of a keyboard punching system. Keys are colored to facilitate operation. Octave groups are read, timbre, green; growth, duration and decay are blue; and volume is yellow.

The punched record consists of rows of holes each of which pass under a brush. The brushes are equipped with springs arranged so that the brush never breaks contact before making contact at the adjacent hole. Thus continuous contact is producded simulating a slot in the paper.

When the paper record is punched and various elements of the synthesizer are set, the next step is recording the output of the synthesizer. The recording system consists of a lateral cutter and 33 1/3 rpm turntable driven by a synchronous motor. The disk recorder is coupled to the paper drum drive by means of a flexible cable synchronizing The synthesizer is purposely limited to the paper record with the disk record. the production of two simultaneous tones. Due to the characteristics of most sounds it is actually limited to a series of single notes, thus simulating any single instrument.

To emulate an orchestra, each individual instrument must be coded and recorded separately and the group of instruments combined. For keyboard instruments the number of separate records required depends upon the number of tones sounded simultaneously. The disc record can accommodate six three-minute recordings. After six complete recordings are made for six different musical renditions, the six are combined into a single recording by means of a double turntable recording system. These six can be combined with six more for 36 individual sounds and then combined for 216 different records on one.

Thus each individual synthesized selection is a separate entity and can be worked on until the operator is satisfied with the product. Levels of individual selections can be adjusted until optimum mixture is obtained. Once a recording is obtained, it can, unlike a group of musicians, be duplicated. Thus the error of one musician, which would cause the late Maestro Toscanini to make the whole group repeat a phrase, would only result in the guilty musicians staying after school.

Results Obtained

Now that we have some idea of how sounds are simulated by the synthesizer, what sounds can and does it produce? Work has been done on simulation of plucked string type instruments towards combining desirable characteristics of banjo and guitar. The tone produced is smoother and more pleasing than conventional plucked string instruments in that contact noise produced by finger or plucker against the string does not exist in tones produced in the electronic system. In piano techniques, more fundamental can be obtained in low-frequency range than is possible with a concert grand. The noise of hammer striking the string with mechanism rattle does not exist. Scratch noise in a violin produced by the bow is eliminated. In wind instruments, the wind noise is eliminated and greater frequency range is obtained. Low frequency instruments such as bassoon and contrabassoon are better produced in their low-frequency ranges. Hi-fi fanatics who long to hear the moisture drip from a french horn may be disappointed by this.

In percussion instruments the objectionable features of disagreeable strike tones and unharmonic overtones are eliminated in bells, glockenspiel, and xylophone. Drum-type tones are produced with a definite pitch and greater frequency range.

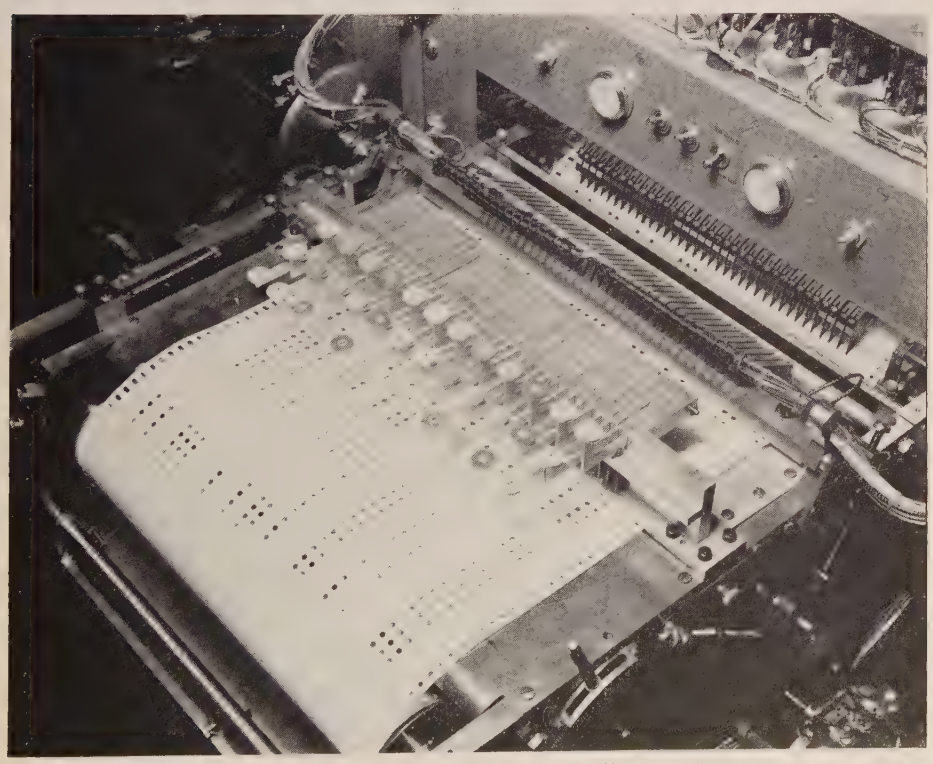
Work on simulating the singing voice has been restricted to simple musical selections. One or more voices separately and in combination with synthesized orchestral accompaniment has been produced. The speaking voice of both mean and women has been produced.

One of the many uses forseen for the synthesizer is to make music for sale in phonograph records. To make an artistic record or a hit, novelty or technical excellence is not alone sufficient. However, the synthesizer can produce any kind of sound that can be imagined. If a person can imagine a hit, the synthesizer will facilitate the production of the hit. Perhaps later modifications will enable the synthesizer to imagine the music as well as simulate it. Until then, we are forced to rely on man's imagination for hits such as "Hound Dog," or "Chickerry Chick."

If a composer has in mind what he wants to achieve, the effects can be obtained by means of the synthesizer, regardless of whether he can play a musical instrument or not. The synthesizer can be used to rejuvenate old phonograph recordings where the master is in poor condition. The old record can be analyzed and synthesized to produce a replica of the old record but without distortion or noise. Imagine hearing Caruso without record scratch.

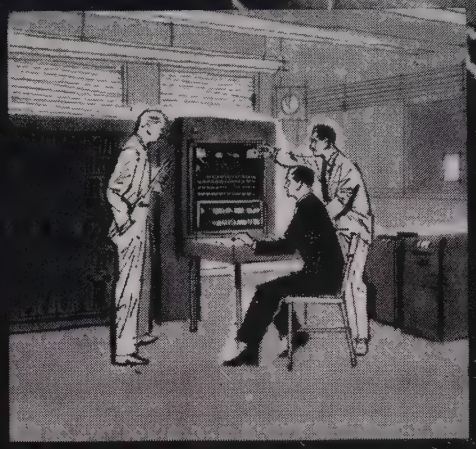
The synthesizer can simulate the performance of an artist who has ceased to perform. Both voice and instrumental musical selections may be synthesized from an analysis of the style and structure obtained from information contained in recordings produced by the artist in times past. If the artist is alive, but is unable for physical reasons to perform, he can supervise the synthesis. If the artist is dead, the style and characteristics of the artist may be analyzed from his records and catalogued for use in simulating the performance of the artist by synthesis. The product may be supervised and monitored by a musician to insure that authentic results are obtained. Imagine Caruso singing "Blue Suede Shoes."

One can see many possibilities for the electronic musical synthesizer, but one can only shudder at the possibilities if the synthesis of musical tones is taken out of the hands of trained, ethical personnel.



THIS 15-INCH-WIDE PAPER TAPE RECORDS all variations on a tone

ELECTRONIC GIANT SQUEEZES THE ERROR OUT OF WEATHER FORECASTING



It's bad news—but pretty soon we may be deprived of our age-old sport of taunting the weatherman for his mistakes.

Reason? A giant electronic computer is squeezing the error out of weather prediction by making numerical weather forecasting possible. Now at work at the Joint Numerical Weather Prediction Unit, Suitland, Maryland, an IBM 701 computer digests thousands of weather-influencing facts daily and computes them at almost incomprehensible speeds.

Making 16,000 additions or 2,000 multiplications every second, the computer forecasts the daily weather with an accuracy that would have required some 64,000 mathematicians thirty years ago. In addition, it encourages meteorologists to tackle problems that once discouraged them because of the staggering mathematics involved.

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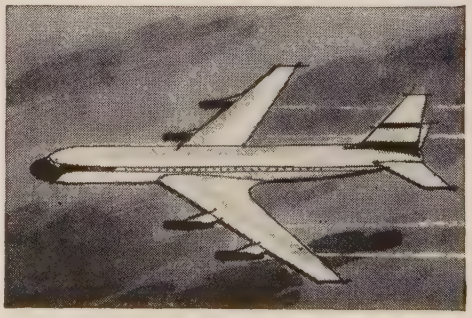


"Flight-testing" without flight: At aircraft plants, IBM computers *pre-test* planes, simulate actual flight conditions mathematically, eliminate hazardous testing.

SKIMMING INDUSTRIAL HEADLINES

edited by Harry Hirsch, E.E. '57

National Engineers' Week

Eleven leading engineering figures have been named as sponsors of National Engineers' Week, Feb. 17-23.

The observance is held each year during Washington's birthday week by the National Society of Professional Engineers. The week has been recognized by President Eisenhower, and by the governors of most states and the mayors of hundreds of cities throughout the country.

The 11 sponsors: Vannevar Bush, former president of Carnegie Institution of Washington; Allen B. DuMont, chairman of the board of Allen B. DuMont Laboratories, Inc.; Charles F. Kettering, General Motors Corporation; James R. Killian, Jr., president of the Massachusetts Institute of Technology; Clarence H. Linder, vice president, General Electric Company; Thomas E. Murray, Commissioner, U. S. Atomic Energy Commission; Royal W. Sorensen, California Institute of Technology; Phillip Sporn, president, American Gas and Electric Company; David B. Steinman, consulting engineer; Charles Allen Thomas, president, Monsanto Chemical Company; and Robert E. Wilson, chairman of the board, Standard Oil Company of Indiana.

The theme for the 1957 National Engineers' Week is "Engineering . . . America's Greatest Resource."

The events of the Week are developed locally by the members of the 41 state societies and more than 300 chapters of the National Society of Professional Engineers.

Scheduled for the 1957 observance are career conferences for high school students, engineering exhibits in store windows and schools, guided tours for students through local industrial firms, and the publication of special newspaper sections on the contributions of engineering to our modern way of life.

Public service programs on radio and TV have been scheduled for the Week, along with radio and TV spot announcements on both local and network time. One of the filmed TV announcements features Atomic Energy Commissioner Thomas E. Murray.

National chairman for the week is John L. Bahr, chief engineer, National Vulvanized Fibre Company, Wilmington, Delaware.

1957 Nuclear Congress

First details of a 1957 Nuclear Congress, described as "possibly the most significant event of its kind ever held in this country" were made public recently. To be held at the Philadelphia Convention Hall March 11-15, the Congress is sponsored by more than 20 engineering and technical societies and will include a concentrated program of more than 200 technical papers, two days of Conferences for business executives interested in atomic energy, and an International Atomic Exposition where new developments related to peacetime nuclear operations will be displayed.

An announcement by T. A. Marshall, Jr., on behalf of Engineers Joint Council which is coordinating the program, also revealed that the American Nuclear Society has joined the 20 organizations which were the original sponsors of the program.

More than 40 major topics will be considered at the Congress, including nclear generating stations, reactors for ship propulsion, disposal of radioactive wastes, production of atomic fuels, legislative and legal problems, atomic energy developments abroad and practical, commercial applications of the atom in such fields as chemical production and food processing.

In revealing details of the program, Mr. Marshall said, "The tremendous scope of this Congress demonstrates the extent to which atomic energy is becoming a day-to-day industrial operation. Rapid growth and even more rapid change in the field have created a demand for a comprehensive program of this kind where specialists and industrial leaders can assemble and, in a short time, bring themselves up to date on new developments. Recent decisions by the Atomic Energy Commission to expedite America's nuclear power program emphasize the fact that we can expect important, constructive results from this Congress for years to come."

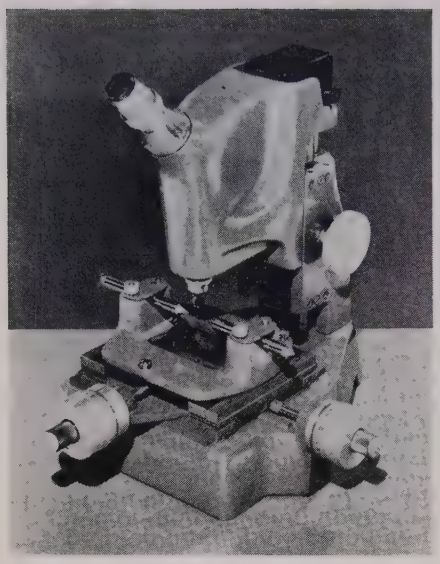
New Testing Microscope

A new microscope for use by machanists and toolmakers in the inspection and measurement of tools, drill jigs, templates and finished parts has been announced by the Bausch & Lomb Optical Co.

Called a Toolmaker's Measuring Microscope, the new instrument offers significant improvements over existing shop microscopes. According to the manufacturer, it provides versatility, convenience, sturdiness and accuracy previously unavailable in its price bracket.

Major advance lies in a unique illuminating system. The illumination source is built-in and the beam of light is directed down through the microscope objective, giving true vertical illumination. A collective mirror under the stage plate reflects the light back into the body tube. As a result, both the surface and the contour of parts may be viewed simultaneously.

Designed for precision measurement in two coordinates, the cross slide stage has a maximum possible range of two inches in the "east-west" direction and one inch in the "north-south" direction.



Toolmakers will use new measuring microscope for fast, accurate measurements

The stage itself rests on ball bearings and its motion is controlled by two micrometer screws.

Standard magnification is 35X, but different objective and eyepiece combinations may be used to obtain other magnifications. A 7/5X protractor eyepiece, and centers which can be aligned with the eyepiece cross-hair are available for increasing the versatility of the instrument.

Electric Watch

A new era in timekeeping was ushered in with the introduction of the world's first electric wrist watch, perfected after ten years of research, development and testing by the Hamilton Watch Company of Lancaster, Pa.

No larger than a conventional wrist watch, the electric watch offers the highest accuracy and dependability ever achieved, and incorporates the first basic change in watch construction in almost five centuries, according to Arthur B. Sinkler, Hamilton president.

The radical structure of the electric watch completely eliminates the mainspring, an integral part of portable timekeeping devices since it was invented in 1480 by Peter Henlein of Nuernberg, Germany. The new watch is the only one in existence which runs without winding or without periodic agitation, Sinkler added.

"The watch movement," he pointed out, "is so exquisitely engineered that a tiny Energizer the size of a small shirt button will run it for a minimum of twelve months. In fact, Hamilton's electric watch would run for more than 20 years on energy that would operate a 100-watt bulb for no longer than one minute."

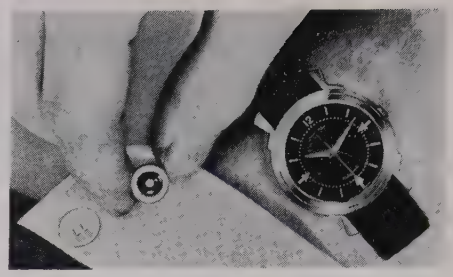
Sinkler called the electric watch a "milestone in Hamilton's program of research and expansion," and predicted it would in time completely replace present-day automatic watches.

The electric watch operates on chemical energy stored in a tiny Energizer, according to Dr. John Van Horn, director of research and development for Hamilton and its Allied Products Division. This energy is converted into electrical power as it releases a stream of electrons through a coil of fine wire fixed on a balance wheel. The electrical energy through interaction with permanent magnetic fields causes the balance wheel to oscillate. This oscillation is the mechanical energy which runs the watch.

"The over-all result is a precise miniature power plant built into the balance wheel, which in turn powers the gears and move the hands of the watch. In the past, the balance wheel only controlled the power furnished by a mainspring. In the electric watch it furnishes its own power as well as controls it," Dr. Van Horn pointed out.

"The essential difference between our motor and the conventional electric motor is that the power plant, combined with a balance wheel, permits the flow of energy to be strictly controlled and the speed of the hands to be held to an accuracy of more than 99.995 per cent," Dr. Van Horn emphasized. "Combined with simplified construction and built-in shock resistance, the motor provides incredibly long life for the watch."

The coil is made of wire only one-fifth the thickness of human hair.



An energizer is held next to small shirt button which it approximates in size

Enough of this wire for 100 watches would weigh only two ounces but would stretch from Dover all the way across the English Channel and well into France.

The tiny magnets used in the electrical system are of platinum alloy and have the highest energy content of any magnet in the world today. They were processed by Hamilton expressly for use in the electric watch.

The electric watch is more nearly free from disturbance by stray magnetic fields than any other watch, according to Dr. Van Horn. "The television service man, a physician with an electrocardiograph or any of the increasing number of people who work with or around magnets will be able to wear this watch with no interference," he stated.

The resulting gold-plated Energizer is designed for long life and lo power. It is 400 times more efficient, in terms of space, than the mechanical energy stored in a mainspring, and does an in-

MOVEMENT OF WORLD'S FIRST electric watch (right) is shown with movement of manually-wound watch

credible amount of work for its size, he pointed out.

"For example," said Dr. Van Horn, "in the course of one year it must open and close the circuit 75 million times. The second hand must be pushed forward 75 million times and the balance wheel must oscillate 150 million times."

The electric watch is more accurate and dependable and has about one-third fewer parts than the automatic watch which has gained great popularity in recent years, he added. "Tests show that the day-to-day accuracy of these new electric watches is far greater than that of automatic or manually-wound watches," he continued.

Also, he said, the electric watch is less complex than the old automatic because there is no winding mechanism or mainspring. The result is a simpler and more efficient operation.

Missile Research

The main design problems facing missile scientists in their missile research and development work today include (1) the nose cone, which houses the warhead; (2) the guidance system, which puts the missile on the right path to the target; (3) the airframe, which forms the missile body and contains the various subsystems nd the fuel; (4) the propulsion system, which provides the power to drive the missile into space.

Of these four problems, that of developing the nose cone is probably the touchiest. When a missile breaks into the atmosphere at speeds in excess of 10,000 miles per hour, forces of heat and pressure are built up. The nose cone is confronted by these forces and is therefore subject to disintegration, loss of control, and loss of functional purpose.

A good comparison can be drawn between the nose cone and a meteor. A meteor, when it enters the atmosphere, usually disintegrates and falls to the earth as dust. This must not happen to the nose cone. It must remain intact and functional.

The enormity of the task of keeping the nose cone under control and functional presents the crux of the knotty nose cone problem. Knowledge in the required fields — aerothermodynamics, aeroballistics, hypersonics, etc.—is relatively meager, yet this knowledge must be extrapolated into unknown technological areas. Consequently, the very frontiers of physics, chemistry, metallurgy, electronics, and other basic sciences must be expanded, and new research tools must be developed to enable scientists to work in areas never before explored.

New research tools being developed by General Electric's Missile and Ordnance Systems Department include unique shock tunnels and ballistic firing ranges to simulate flight conditions for the nose cone. Many other test equipments and processes, still highly classified, are being developed for this work.

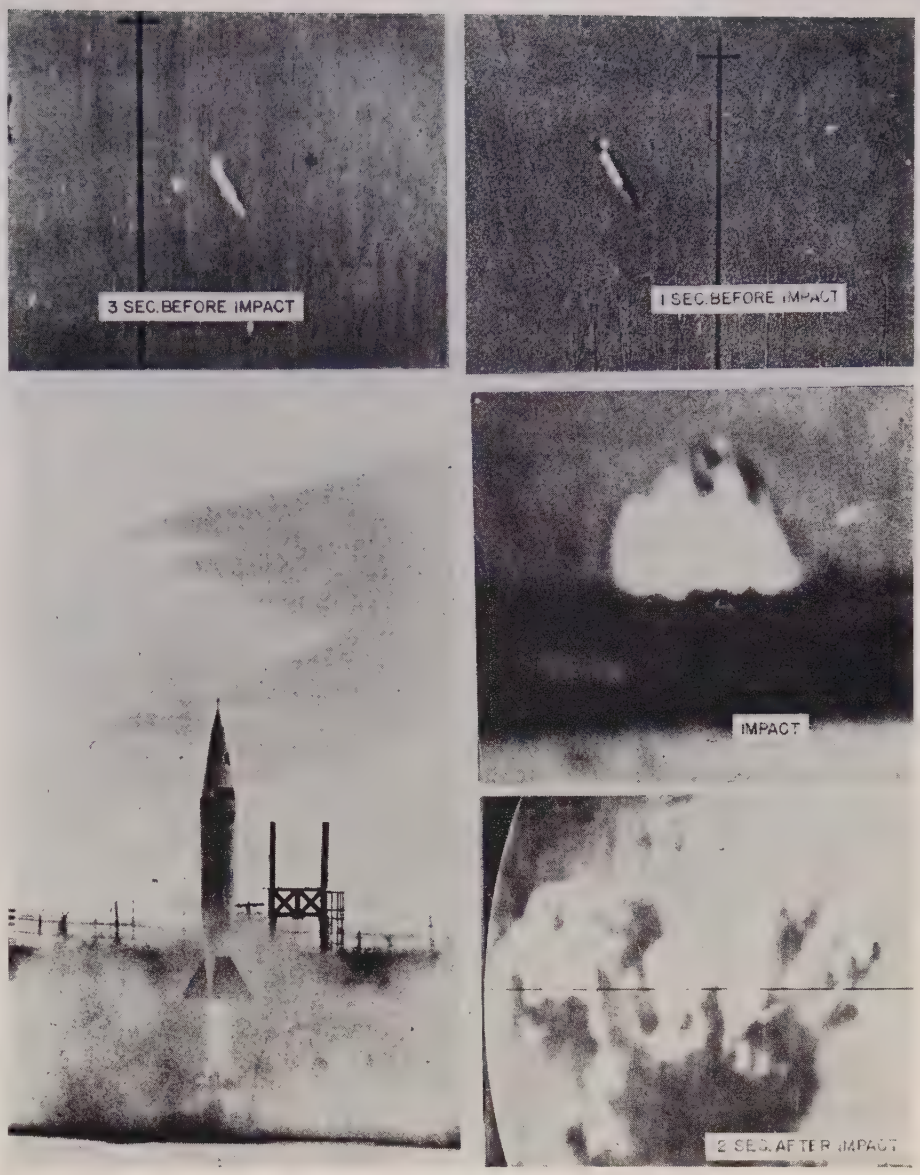


PHOTO SEQUENCE ILLUSTRATES damage to missile nose cone

A very valuable method of recording tests, particularly those held beyond the range or capacity of the human eye, is that of photography. Though not completely foolproof, the camera is still useful for even the exacting tests on the nose cone. The composite picture accompanying this article shows the "life story" of a missile from firing to impact. Taken from a range of fifteen miles by a Signal Corps camera using telephoto lenses, it is the first picture of the impact of a large missile.

The missile is the Hermes A-3, a research vehicle developed by Army Ordnance. Data gathered on Hermes are being used in designing components and sub-systems for missiles under development today.

Hermes, during the flight shown here, was traveling at the realtively low speed of Mach IV, yet the heat and pressure built up at this speed is sufficient to cause severe heating and partial disintegration. These photographs show that Hermes was still functional upon arrival at the target.

Some engineers feel that the nose cone will tumble and go out of control These pictures show that this supposition is not necessarily true.

What is the answer to the problems of distintegration and loss of control? Must better heat-resisting alloys of existing metals be found? Can the nose cone be slowed down upon re-entry so that danger of friction will be reduced?

These and many more questions plague the missile scientist. It is well known that some designs offer a "cushioning" effect, but the problem of slowing a body plummeting to earth at 10,000 miles per hour to slower and safer speeds will demand extensive imagination and creativity—the touchstones of a successful research and development program.

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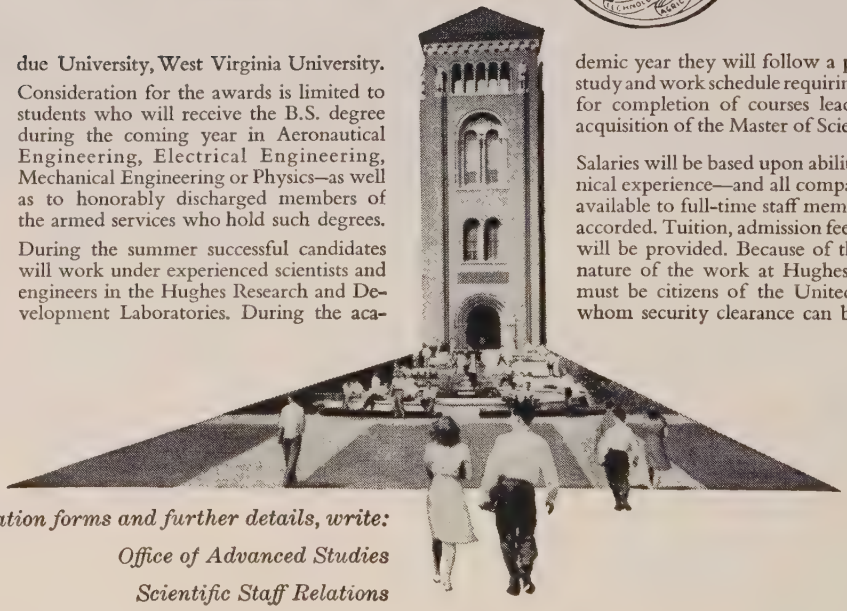

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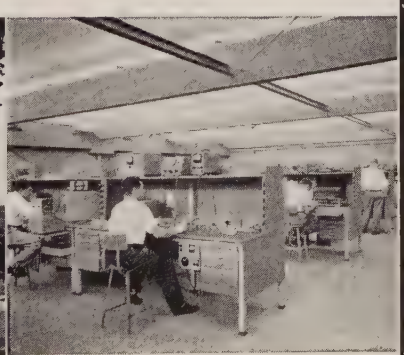

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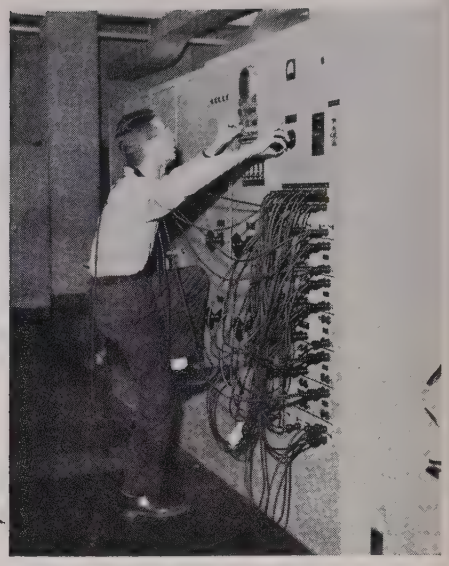
Operation of Radar Equipment

A Layman's Guide



Nothing ever goes wrong with the receiver!

(The following article was left in our office with a note that it must be read THOROUGHLY for the most enjoyment.—Editors)

The AN/14Q-2 is an entirely new development in the field of radar. The basic components are a transmitter and receiver, mach mounted on a separate bipod.

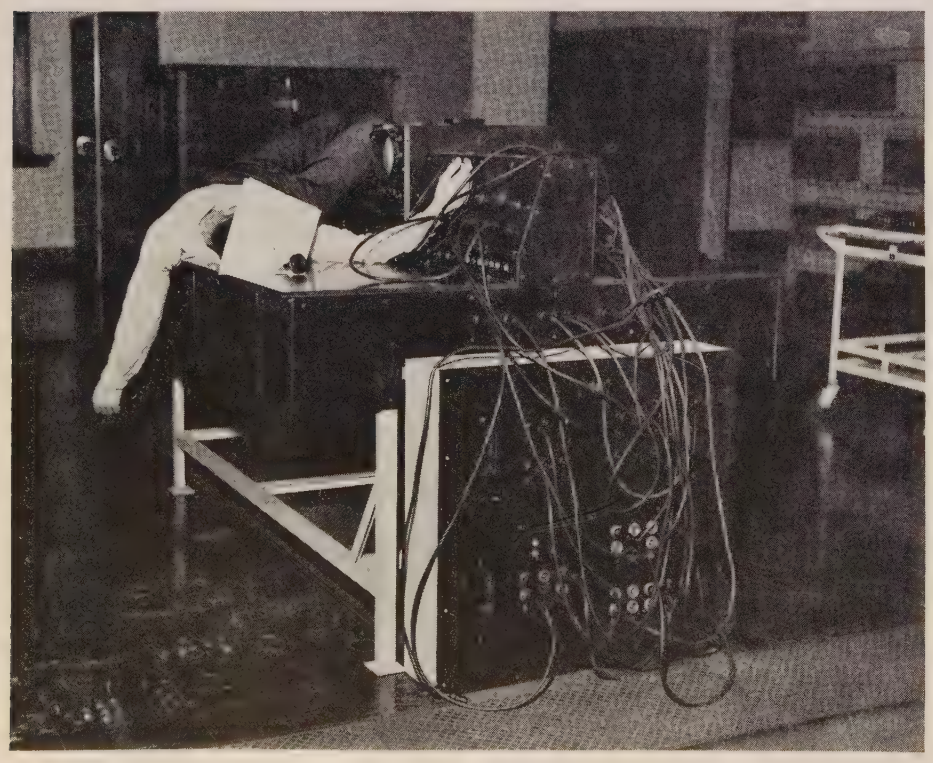
Description of Components

The receiver is located in a handsomely finished cabinet, equipped with two main tuning dials, a coast button, and a resonant cavity type of receiving waveguide.

The transmitter consists of a less handsomely finished cabinet, more of a utility model whose most prominent feature is the radiating monopole antenna located at the lower end of the chassis. This antenna is fed thru a five (5) millimeter waveguide from the twin transmitting tubes which are operated in pushpull.

Installation and Adjustment

The equipment may be operated while mounted on the bipods when time is insufficient to prepare a more suitable installation, although optium performance is not to be expected under such conditions. In general, the equipment should be laid along the ground. The bipods may be folded up or left extended along the ground but are rarely ever detached.



DON'T FALL ASLEEP at the switch! (Photos by Dave Yates)

There is an almost endless variety of suitable positions for the components. The more experienced operators feel that the most satisfactory results are obtained when a new arrangement is tried at least once a week. In most of the set-ups it is found that the receiver bipod, which is adjustable thru an extremely wide range, can be interlocked with some portion of the transmitter chassis thus providing firm support for the entire installation. The site of the installation is important. The equipment should be bedded down on a surface which is soft but not too springly. Excessive springiness of the foundation may cause spurious oscillations which interrupt the PRF (Pulse Reptition Frequency), and may even cause premature transmission.

Preliminary Adjustments

To prepare the equipment for operation it is advisable for the operator to manipulate the main receiver tuning dials continuously while the receiver is warming up. The operator should also touch the grip cap of the local oscillator which is located just forward of the resonant cavity. If the receiver emits a low sigh, excellent operation is assured.

Practically no checks are possible on the transmitter, since these units are generally of such rugged construction that they seldom fail in action. Some operators give the transmitter a dry run with a dummy waveguide, but this is not considered a reliable test. Operation into a sand load is strictly forbidden as this will almost invariably ruin the radiating monopole.

Operation

The distinguishing feature of the AN/14Q-2 is its mode of operation. Unlike the majority of radar sets, the PRF is continuously adjustable over a wide range, increasing slowly, decreasing

again, and going thru several cycles of increasing and decreasing PRF. During this time, if the receiver is operating properly, the resonant cavity will become highly receptive to the transmitted frequency. In rare cases a receiver is found which because of negligence at the factory during inspection retains a protective shutter in the resonant cavity. This shutter is useless and has been known to cause inefficient operation of the receiver and transmitter. A strong PRF sensed by the receiver will generally destroy the shutter to provide satisfactory operation. Very few receivers, which have not been serviced properly, are found in the field today.

A common mistake on the part of inexperienced operators is to start the transmitter off at too high a PRF. Entirely apart from the strain on the chanism, this type of operation is inadvisable as it invariably results in premature transmission. Repeated strains of this sort ill generally result in the complete breakdown of the receiving system, which in general will never again operate satisfactorily with that particular transmitter.

Some operators are able to make a continuous check on the equipment by inserting the main tuning knobs in their ears and listening for unusual set noises, arcovers in rotation joints, etc. This is only possible with the larger of "longstemmed American Beauty" type of receiver.

In proper operation the cyclically varying PRF will gradually rise to a tremendous crescendo. At this time a transmitted pulse of approximately ten (10) megawatts is generated, the radiatting element arcs over, and various parts of both transmitter and receiver become virtually incandescent. The equipment must now go off the air for a short period of maintenance, repair and general policing of the area. The operator should pay careful attention to the receiver, making sure that all capacitors discharge slowly and that the equipment is gradually brought back to the quiescent condition. One of the most frequent causes of set failures is the tendency of the operator to go to sleep at this point without remembering to turn off the receiver. This causes the receiver to blow several fuses, and may even cause violent erratic motions of the receiver bipod, causing damage to the base of the transmitter.

Operation may be resumed after a short lapse of time. If overall performance is unsatisfactory, it is wise to check the transmitter output. In any case the trouble, whatever it is, will always be located in the transmitter. Remember, after the first or trial run, NOTHING EVER GOES WRONG WITH THE RECEIVER!

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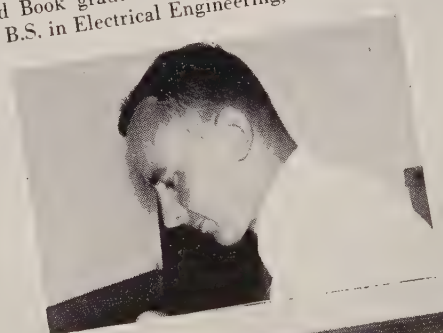
4. '53 — Transfers to newly formed Advanced Development Dept. to engage in theoretical research and development.

3. '52 — Works on analysis of vacuum tube problems.

2. '51 — Joins Sylvania's Buffalo Division; after 3 months orientation period, picks the job he wants — in Tube Applications Department.

1. Everard Book graduates from the University of Illinois with a B.S. in Electrical Engineering, class of 1951.



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MAGICIANS

. . . *and the Slide Rule*

by Gus Weber, UI alumnus, Ensign, U.S. Navy

Robert-Houdin, the most famous magician in the world, looked down at the small chest on the platform before him, then back to the face of the Arab. The French Government had sent Houdin to Algeria to destroy belief in the pretended miracles of the Mirabouts, a clan of Arab magicians who had attracted scores of followers. Houdin was countering their magic with some of his own.

"If you are strong, perhaps you can lift this chest," he told the Arab. The Arab smiled and lifted it with no trouble.

"I can make you weaker than a woman," said Houdin, "Try now to lift the box."

The Arab tried to pick it up, straightened up, then bent over for another attempt. The box wouldn't budge. Spurred on by his friends, he put his feet astride the box and braced for a powerful strain. It seemed that the box would fly to pieces under the effort.

But as he touched the handle, his arms contracted to his chest and his knees buckled. In another second he was crying for mercy, and the audience was convinced that the European's miracles were supreme.

Robert-Houdin's foolery with a magnetic box and an electric shocker was not the first time conjurers have engineered their tricks according to principles of physics. From the high priests of Egypt to the television performers of today, magicians have opened doors, started fires, floated human beings in the air, made elephants disappear, and raised enough departed spirits to make Bridey Murphy look like "Portia Faces Life."

Magicians have almost always been the engineers and physicists in primitive societies. The medicine man alone was supported by the community, and during leisure hours he came up with some startling discoveries.

Finding that certain stones, when struck together, produced sparks, he would "make lightning" for his disciples. Noting that animal fat repelled water, he would dip objects into a stream and "make the water dry."

Even in recent recorded history, we can find examples of science applied to magic. Benjamin Franklin once announced that he could still a turbulant pool of water merely by shaking his cane over it. Franklin hid a supply of mineral oil in the hollow cane and unobtrusively released it over the pond. With oil on its surface, the water calmed itself and earned for the young inventor a reputation as a magician, because he applied his physics to foolery.

Not until the Industrial Revolution and the Mechanical Age did scientific conjuring reach the stage. As soon as scientists discovered a new principle, the great magicians of Europe exploited it for their wizardry. Early manufacturers of bottle batteries, leyden jars, and induction coils were hard pressed keeping up with the demand for their products.

And what were some of these feats of magic? Among the popular ones was the "light and heavy chest," the one that Robert-Houdin used in Algeria. Onlookers who could see no connection between the chest and its platform were baffled by its behavior. Going a step further, Robert-Houdin "gave and took away strength" instead of making the chest heavy or light.

Another favorite was the "crystal cash-box," suspended on cords. The chest was transparent, save for an ornate design on top common to many Victorian utensils. Concealed under the design was a small magnetic coil, hold-

ing several coins. Current came down wires in the center of the ornate cords. When the magician or his assistant broke the current, the coins fell into the glass from "nowhere."

Many times, instead of using a scientific principle, the performer invented one of his own and credited his miracles to it. When physicians first used ether as an anesthetic, Robert-Houdin announced that he had perfected an ether that made the patient not only light headed but light bodied as well.

While Robert-Houdin's son pretended to breathe vapors from a bottle, an assistant backstage poured real ether on a hot shovel to provide an authentic smell for the audience. Houdin then placed the boy on a stool with poles beneath his armpits. When the lad was sufficiently "anesthetized" Houdin removed the stool. The boy remained suspended by his arms on the poles.

The magician then removed one of the poles. The lad, supported by one arm on the pole (and a strong steel girdle beneath his clothing secured to the pole). Robert-Houdin then lifted the boy upright so his feet pointed out straight horizontally. The girdle transferred the boy's weight to the pole.

With the lights low, Robert-Houdin dramatically removed what looked like the final pole, and his son remained in mid-air. Few spectators realized that the last "pole" was merely a bright metal shell, and that the blackened original pole was still supporting the boy. Yet doctors from all over the world sent requests for the amazing ether to Robert-Houdin. "The suspended lady," as the trick is called today, is still popular.

Following the Industrial Revolution, a new mystic medium (or mediums) arose to demand the scientists talent. It was the least physical and most fraudulent application, or misapplication, of the craft. We know it as spiritualism.

Unlike other magical media, spiritualism demands that its followers approach it with an honest desire to be fooled. The most obscure goings-on that could never survive in the footlights thrives in the darkness of the senance. Conjuring was back where it was born, deep in the superstitions of the human mind.

Modern spiritualism was founded in New York by three girls who could crack their toes much as other people can crack their knuckles. People came from miles around to see the girls, who claimed that the mystic rappings were a form of communication with the dead. By the time they admitted the source of the sounds, the fad had caught on.

Magicians who didn't possess the physical faculties of the founders resorted to another device to produce rappings — the electromagnet. Through dummies, wooden hands, empty boxes, and "rapping" tables, the spirits made their presence known with the regularity (and technique) of a telegrapher's key. The magnets, tapping out earnings to the beat of millions of dollars a year, became a big business.

And with the tappings came other mysterious doings. Radium paint gave a more visible manifestation of the departed spirits than the rappings. Loudspeakers talked in more understandable words than code. Powdered magnesium provided flashes of light and billows of smoke that would have done the devil proud. Later photographers were to use the same powder for flash pictures.

For years the spiritualists, encouraged by patronage from the great, ran rampant. Sir Arthur Conan Doyle was an adrent missionary for the art. It remained for a great showman to hold the mediums up for what they were. He was an American.

When Harry Houdini began in show business, he took the stage name from Robert-Houdin, whom he idolized. As a young performer, Houdini was amazed to find people willing to pay for spiritual senances. In later years, when he had acquired a reputation and a better understanding of the mediums' devices, Houdini became a relentless foe of the spiritualists.

While some of his own tricks could have passed for the work of the devil himself, Houdini offered a reward of $10,000 to anyone who could produce a spiritual trick he could not duplicate. A few accepted the challenge; many did not. No one ever collected.

Other magicians in other times have used traps, levers, mirrors, springs, wires and apparatus that would give pride to the best mechanical engineering lab. Howard Thurston made such extensive use of the trapdoor in his act that whenever he moved to a new location the manager of the theatre where he had performed would hire a young boy to walk back and forth over the stage. If any trapdoor were to open it would do so then and not in the middle of the first dance act.

Modern magicians have used carloads of apparatus to deceive their public. Harry Blackstone had a giant buzz-saw for sawing a woman in half the modern way. Others have used every conceivable machine from finger choppers to railroad locomoties.

But whenever a magician uses science to conduct his act, he is faced with the problem of uncertainty. There is always the chance that the powder will fail to ignite, that he will end up a laughing stock instead of a acclaimed performer. This is especially true when amatuers attempt to invade the area of wizards.

A number of years ago, in a New Jersey boys' camp, the author decided to use some high school chemistry to entertain the young campers. The occasion was the annual campfire, when prominent city officials as well as the camp directors made the long trip into the wilds to witness what promised to be an impressive ceremony. To make the evening complete, the author decided to let the Great Spirit ignite the camp fire.

To put the Spirit in the proper spirit, I dug a trench from the council ring to the bench where the dignitaries would sit. I laid a small pipe with a wire running inside it in the trench, then covered and smoothed the trench to leave no indication of the preparation. At the base of the fire, I put a mixture of potassium chlorate and sugar, and above this mixture, on a swivel, went a small vial of concentrated sulphuric acid. A thread tied in a way to upset the vial was tied to the pipe inside the wire. The fire was then built up around the contraption, and as an aid to the Great Spirit, was thoroughly drenched with kerosene.

That evening the campers, bedecked with Indian garb, streamed into the council ring in awe. When the guests had been seated, I arose to begin the ceremony. The customary opening was a plea to the god Wauconda to "send us not the rain." Hardly had the plea been sounded when a few spatterings of raindrops indicated that this prayer wasn't too successful. But the clouds held their moisture and I decided to go ahead with the fire, out of sheer vanity if nothing else.

I circled the fire once, then lifted my arms in what I thought was quite an imposing stance at the head of the fire. Just as I was about to start the ritual, my assistant whispered that since the fire had been "too thick" to burn properly, he had removed a lot of the center wood. My heart sank! Banking on the kerosene, I didn't build up a proper kindling.

But it was worth a try. In my best Indian voice, I asked, "O, Great Wauconda, if we be worthy, send us fire. . . from. . . heaven!" Nothing happened. I gave the string another jerk. It was fast somewhere.

There was only one thing to do. I reached under the logs and tipped the vial of acid by hand. And then the fireworks began. In a second, the fire was a mass of flames. The campers were silent in awe. But the lost wood had taken it toll. In another matter of seconds the kerosene was burned off and the fire died.

A sorry magician made one last plea, for a different type of magic fire-starter —a match.

Like the rest of the world, the magician knows how to use modern developments to further his craft.

Who knows but some wizard of the future may put you behind a screen, and before the gasps of the crowd make you disappear, while only rendering you invisible with the rays of the latest molecular disintegration gun.

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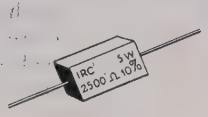
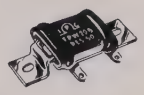
Type BT Fixed Composition Resistors	 Low Power Resistors
Type HFR High Frequency Resistors	 High Power Resistors
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BRAINTEASERS

edited by Don Georgi, E.E. '59

1. It seems that Stauss and Cornell had invested some money in a small grove of box elder trees and now were having some trouble among themselves. They had ben talked into the venture by Hic Krysinger and Bill Bahlin, two timber engineers who spent the summer in the forests of the West. Bogall Cornell, who, by the way, was once a forester, planted the 25 box elders as shown:

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J. C. Stauss agreed to water and care for them. He was aided in this by Dr. Almer Mirth, who checked constantly for the presence of harmful bacteria. But now Bogall and J. C. had agreed to divide them as follows: Bogall would have 8 trees; J. C. would have 5 trees; and they would use 12 trees as a refuge for homeless box elder bugs. This would have been easy enough but J. C. Stauss wanted his five trees in the shape of a prefect cross, so that he could pretend they were a set of coordinate axes and run up and down them while doing velocity and acceleration problems. (J. C. is a bit eccentric.) He also demanded that a fence be placed completely around his trees and the fence not touch any of his 5 box elders. Bogall Cornell, of course, didn't want the fence touching any of his 8 trees, either. It looked like a knotty problem.

2. Assume the loss of head water flowing through a pipe to be proportional to its diameter. If the loss of 100 feet of 2-inch pipe is p2 feet, what will it be for a 4-inch pipe 50 feet long?

3. A farmer, having a son who would do little work, gave his son 50 potatoes and told him that as soon as the potatoes had been arranged in the following manner he would be free for the rest of the day. The son was to put all of the potatoes in a straight line. He was to take the first potato and set it beside the basket the potatoes had come in, put the second potato a yard in front of the first one, return to the basket and get a third potato to be placed 3 yards in front of the second, return again to the basket and get a fourth potato to be placed 5 yards in front of the third one, and the continue placing potatoes in this manner until all had been used. How far did the lazy son have to walk in all his trips to the basket and back?

4. An irregularly shaped courtyard is bounded by four walls of 10, 12, 14, 16 feet length and the angle between the first two is 70 degrees. If the cost of paving is 50c per square yard, find the cost of paving the courtyard.

5. A motor car company advertises their automobile as stopping on a 58% grade. Compute the angle that the road makes with the horizontal.

ANSWERS FOR JANUARY

1. A, B, and C are the three philosophers. A thought: "Since B laughs he thinks his face is clean. Since he believes that, if he saw my face was clean also, he would be astonished at C's laughter, for C would have nothing to laugh at. Since B is not astonished he must think that C is laughing at me. Hence my face is black."

2. The dalquid holds more blumph than the quiddal. It holds exactly 4 times as much. Reducing the dufis to their equivalent in plups, we find that a quiddal holds only four cubic plups, while the dalquid, whose top is 16 square plups, has a content of 16 cubic plups, since it is one plup deep. If blumph is liquid or granular, the dalquid holds exactly 4 times as much as the quiddal. However, if blump comes in chunks measuring more than one cubic plup each, none at all would fit into the quiddal, whose top is only one square plup. Each of these is a PARALLELEPIPEDON.

3. The man seated four men, 16 women, and 80 children to fill his restaurant, and take in $1.00. If you worked the problem algebraically, you probably found that it was quite lengthy. For this reason, we will mail anyone who is interested the complete solution, just drop a line.

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5. The brakeman's name cannot be Robinson. The brakeman's next door neighbor cannot be Jones because it is impossible to earn *exactly* one third of $10,000. Therefore Mr. Jones lives in Chicago and the brakeman's name is Jones. Smith cannot be the fireman and therefore must be the engineer.

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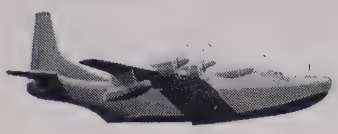
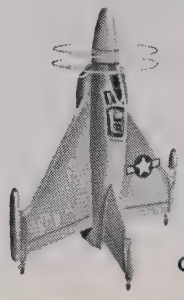

Convair R3Y-1 and R3Y-2


Convair XFY-1

Lockheed C-130

Northrop F-89D

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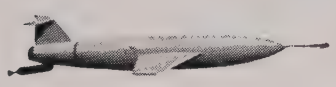
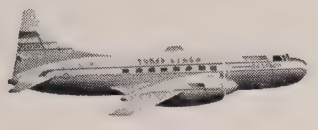

Martin TM-61 (missile)

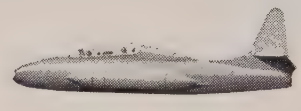
McDonald F3H-2N

Chance Vought Regulus (missile)

Douglas RB-66 & B-66


Allison Turbo-Liner

Martin XP6M


Lockheed T2V-1

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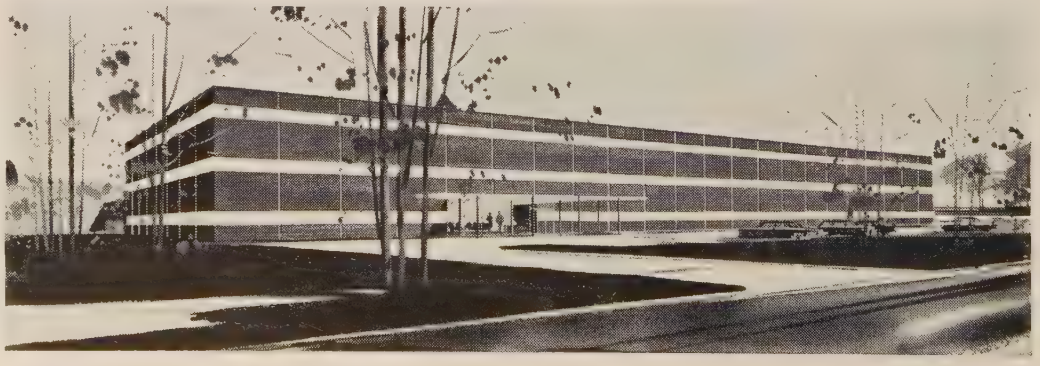
OUR ENGINEERS WORK HERE

This is our Administration Building, the hub of the new Allison Engineering Research and Development Center in Indianapolis.



Tech Reviews

edited by Mike Coleman, M.E. '60

Professional Engineer's Examination, Questions and Answers

By William S. La Londe, Jr., Licensed Professional Engineer; Chairman, Department of Civil Engineering, Newark College of Engineering. Published by McGraw-Hill Book Company, Inc., 1956, 462 *pages,* $6.50.

This book is an authoritative guide to help engineers prepare to pass licensing examinations in the proved rapid, easy manner. Questions and answers prepared by an examination expert show exactly the type of questions which will be asked. These readily show the areas where you can improve your knowledge —before you find yourself in the examination room.

There are over 500 questions selected from actual examinations for the Professional Engineer License, the Land Surveyor License, and the Engineer-in-Training Certificate. For every question there is a detailed answer of the type examiners accept and credit. These questions are representative of the examinations being given now in all states, covering such fields as mechanical, electrical, civil, structural, and chemical engineering, and including engineering economics and land surveying.

This book is an excellent guide for all who are interested or required to obtain a Professional Engineer's License.

* * *

Color Television Engineering

By John W. Wentworth, Manager, Television Terminal Equipment Engineering, Radio Corporation of America. Published by McGraw-Hill Book Company, Inc., 1956, 448 *pages,* 296 *illustrations,* $8.00.

Here is a book for engineers and technicians already familiar with monochrome television, who want to gain a working knowledge of the special processes, techniques, and equipment of color television. Based on sound standards in the field, the book takes the reader from the basic principles of color and color sensation, right through to the actual transmitters, studio equipment and receivers reproducing color images in the set-owners home.

The reader will gain an understanding of both the physical and psychological aspects of color, colorimetric techniques, electronic principles, principles of color television transmission systems, and appartaus and circuits.

Color television theory is explained in simple and largely nonlmathematical forms. The block diagram approach is used extensively, and step-by-step derivations lead the reader gradually from familiar principles of monochrome television to the more complex techniques of color television.

* * *

Physics and Mathematics

Edited by R. A. Charpie, Oak Ridge National Laboratory; J. Horowitz, C. E. A., Saclay; D. J. Hughes, Brookhaven National Laboratory; and D. J. Littler, A.E.R.E., Harwell. Published by McGraw-Hill Book Company, Inc., 1956, 398 *pages,* $12.00.

This volume contains the basic physics of fission and therefore represents the foundation of knowledge on which the development of nuclear energy rests. In this particularly valuable book, the results of the efforts of all scientists in the world are summarized. Essentially, this volume represents a careful evaluation and distillation of the results presented at Geneva on the neutron physics both to reactor design and on the application of this basic knowledge to the practical arts of critical assemblies and reactor calculations. In addition, the book also encompasses the outcome of many fruitful informal discussions which the authors had at Geneva with all the active scientists working in these fields.

In its initial phase, this volume collects and critically compares the results obtained in all laboratories of the world regarding the properties of fissionable materials under neutron bombardment. The book then reviews the theoretical interpretation of these data and of the general conclusions which one can draw from the observed material. This information is followed by a large section devoted to the interaction of neutrons with other than fissionable materials and dealing with extensive discussions of the wide field of neutron scattering and absorption. Delayed neutrons are discussed, and the volume concludes with an important coverage of the properties and the theoretical study of critical assembles of different types.

* * *

Electronic and Radio Engineering, Fourth Edition

By Frederick Emmons Terman, Professor of Electrical Engineering, and Dean of the School of Engineering, Stanford University. Published by McGraw-Hill Book Company, Inc., 1956, 1078 *pages,* 694 *illustrations,* $12.50.

This book provides a single reference source covering the entire field of electronic and radio engineering. It brings you concrete treatment of fundamental engineering principles—introduces detailed explanations of frequency modulation, television, pulse techniques, and exploitation of the higher frequency parts of the spectrum. Over 1000 pages and almost 700 illustrations bring the reader clearcut descriptions of everything from fundamental properties of electron tubes, tuned amplifiers, and vacuum-tube oscillators, to generation of special wave shapes, radar and radio aids to navigation, and television.

With this volume it is possible for the engineer to solve complex problems in electronic and radio design and research. This famous book has been completely rewritten to bring you the information you need on frequency modulation, television, pulse techniques, and the higher parts of the frequency spectrum, in addition to fundamental principles in the electronic field.

Every chapter has been revised to conform to progress made in electronic and radio engineering. Hundreds of excellent illustrations—curve charts, diagrams, graphs, drawings, circuit diagrams, and tables—reflect current needs and practices.

The material covered provides a complete exposition of the fundamental principles of electronic and radio engineering. The emphasis on general techniques in electronics enables the student and engineer to explore the tremendous possibilities now open in the electronic field.

It will be found that the completely revised edition of this popular and well-known book combines the wealth of dependable, basic information, which made the previous editions famous, with the material needed to grasp modern developments and exploit their possibilities.

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2-$25 Awards

Two cash awards of $25 each will be awarded to the author of the best TECHNOGRAPH staff article and the best non-staff article submitted to the ILLINOIS TECHNOGRAPH.

Rules:

1. Articles must be submitted by the author not later than April 12, 1957.
2. It must not have been previously published.
3. It must pertain to engineering in some way.
4. All articles must be doublespaced typewritten.
5. Technograph staff members are eligible for only one of the prizes.
6. Some articles will be printed in the TECHNOGRAPH.
7. None will be returned, but they will be kept on file and may be printed later.
8. Please include pictures, if possible, and permission for us to use them.
9. Any number of articles may be submitted by the same author.
10. The Technograph editorial staff will be judges for the non-staff articles.

Notes:

1. Ten typewritten pages with pictures makes three pages in the magazine.
2. Use rhetoric department punctuation and capitalization.
3. Many national companies will be glad to send you photographs and information.
4. Get started now and get several articles written and submitted by April 12, 1957.

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TECHNOCLIPS

Every year in March, the College of Engineering at the University of Illinois throws open its doors to the citizens of the state, particularly those of high school age, for its Engineering Open House.

As the student "mouthpiece" of the College of Engineering, *Technograph* tries to give the advance news of Open House early enough so interested students may come to Champaign and see the big show.

This year's Open House will be March 15 and 16. Many have been working since the start of last semester preparing for this big weekend which includes the annual St. Pat's Ball with its selection of the honorary Knights of St. Pat and the Queen of the Ball, the engineers' reigning beauty.

Most of this month's *Technograph* is dedicated to Open House. We have an article on Open House itself, with as much advance information as we could obtain before deadline. A two page map of Engineering Campus is also included to formal familiarize visitors with the sights to be seen.

Articles are also included on some of the operations of the College of Engineering that go on day by day and are not specially geared for Open House Weekend. These include a look into Physics research by Jim Kries, associate editor and an engineering physics student; Mining and Metallurgy, by Phil Hicks, Pre-Med student, and Don Georgi, business manager and electrical engineering student.

Editor Harry Hirsch and photographer Dave Yates, both EEs took a quick look at the Foundry and Mechanical Engineering Labs. Dave also did most of the photo work for the Physics and Mining and Met stories.

Two senior seminar reports from the Aero Engineering department show what work students do on a literary research level.

On the industrial side of the engineering world, we have our latest industrial news in Skimming Industrial Headlines, and Harry Hirsch's article on the Electronic Music Synthesizer. This last story is an example of improving on man's efforts to obtain pleasing sound, until poor man is almost entirely out of the picture. While such a development is not viewed in an alarmist's light, it should make one stop to think about this trend towards eliminating man from man's works. Written on a basis of technical writing or engineering with a conscience, we hope the article will make readers stop and think that while its fine to increase quality and efficiency by electronic means, one must not forget poor little man, who is responsible for all this development.

Our Technocutie is gracing the pages as usual, bidding all a cordial welcome to Engineering Open House.

In future issues we shall examine Computers on Campus, with features on the use of IBM cards, the Illiac, Network Analyzer and other sundry automatic gadgets. April is featured as "Aggies and Archies" month with features on these little-publicized departments of engineering.

Our windup issue in May will be a send-off to seniors with features on the Engineering Placement offices and jobs for engineers.

So stick around. We think these and other features in Technograph will make it interesting reading during the coming semester.

A newly created papa received the glad tidings in a telegram: "Hazel gave birth to a little girl this morning; both doing well." On the message was a sticker reading: "When you want a boy, call Western Union."

* * *

He was sitting at the bar, downing one after another and laughing boisterously. Every so often, as he mumbled to himself, he would hold up his hand in protest. Finally the bartender's curiosity got the better of him. "What are you doing?" he asked. "I'm telling myself jokes," was the reply. "But why the hand in the air?" "Oh, that's when I stop me if I've heard it before."

* * *

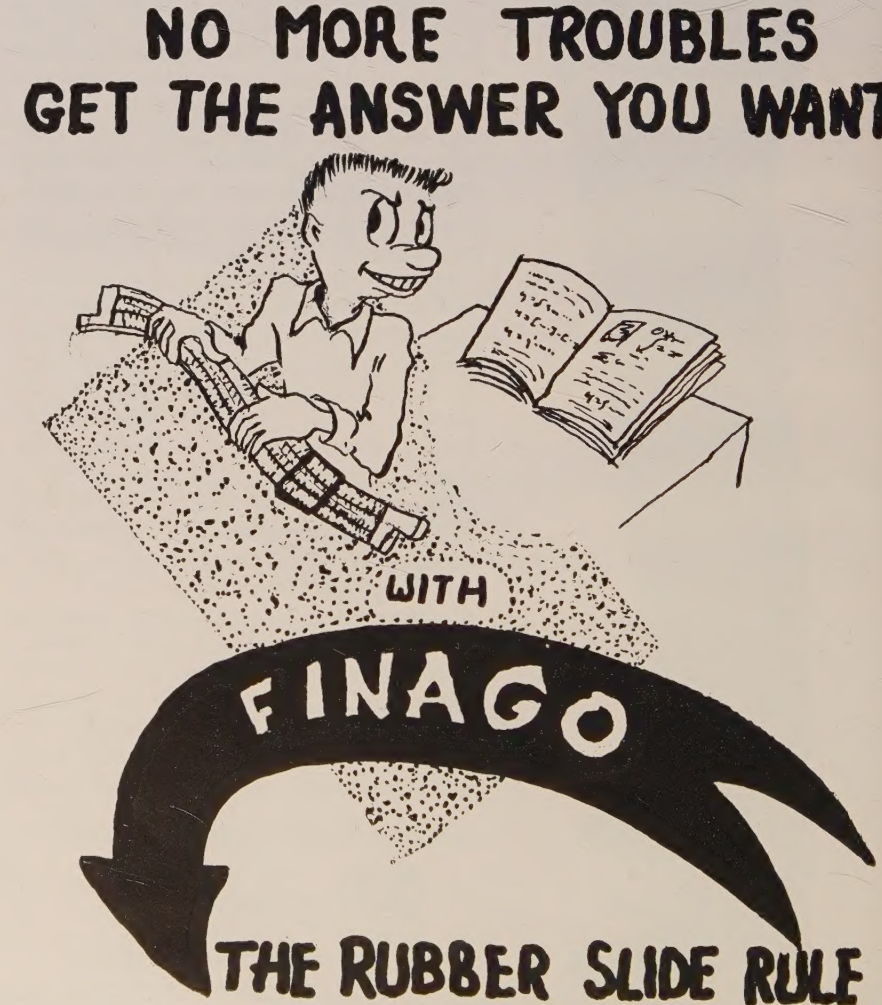
Mary had a little dress
A dainty one and airy
It didn't show the dirt a bit
But, wow, how it showed Mary!

* * *

She: "Oh darling, the baby swallowed the matches. What will we do?"
He: "Here, use my cigarette lighter."

* * *

He looked them over carefully: electric bill, cleaners and so on. Everything was clear except for one item which read ESP, $24.50.

Warily he asked, "What does ESP mean?"

"Error some place," came the better-half's reply.